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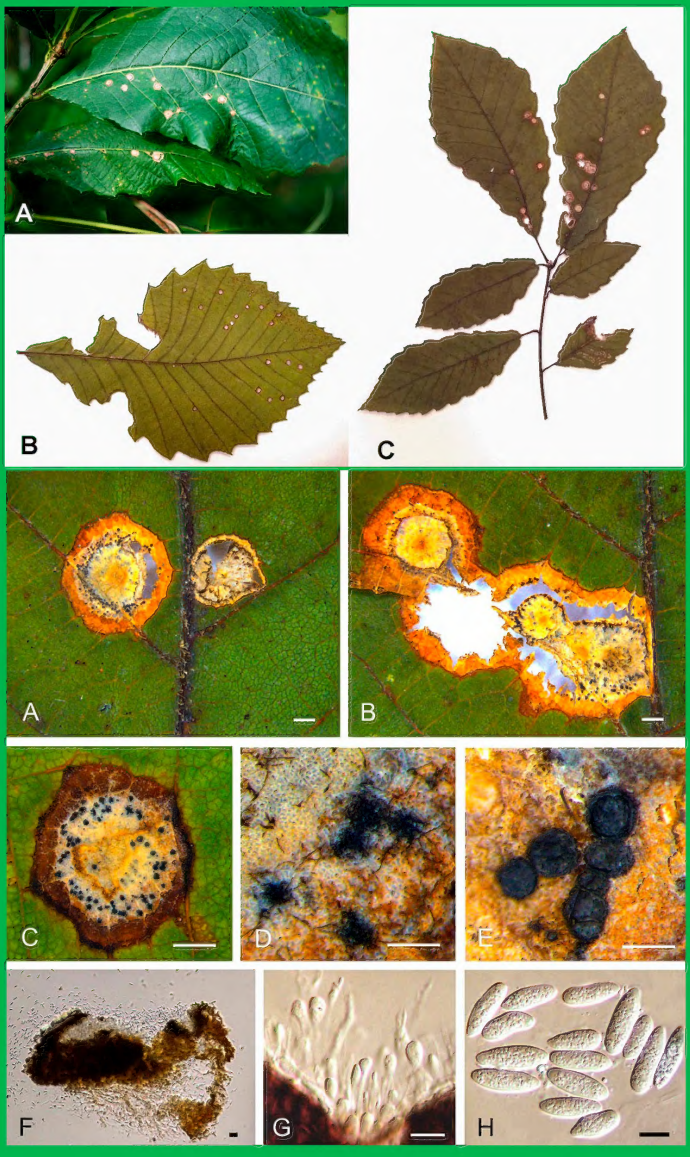

Botryosphaeria qinlingensis sp. nov. from *Quercus aliena* var. *acutiserrata*
(Liang & al.— PLATES 1 & 3, pp. 465 & 469)

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MYCOTAXON

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was issued on July 3, 2019

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Reviewers — volume one hundred thirty-four (3)

The Editors express their appreciation to the following individuals who have, prior to acceptance for publication, reviewed one or more of the papers prepared for this issue.

Artur Alves
Flavia Rodrigues Barbosa
Rafael F. Castañeda-Ruiz
Roger T.A. Cook
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Marcelo A. Sulzbacher
Susumu Takamatsu
Xinli Wei
Ze-Fen Yu
Xiu-Guo Zhang
Andrea Paola Zuluaga Cruz

Errata from previous volumes

Volume 104

pp. 97–101 FOR: *Skeletocutis luteolus* READ: ***Skeletocutis luteola***

The 2008 paper entitled "*Skeletocutis luteolus* sp. nov. from southern and eastern China" by Cui & Dai incorrectly presents the masculine form of the epithet. The species name should be corrected throughout (and elsewhere) to *Skeletocutis luteola,* the feminine form, to agree with the feminine genus.

Errata in current issue (134–3)

Cited below are mistakes present in files submitted for final review but not detected by the authors until after the paper was in press.

p. 535, line 24 FOR: porpidia-type READ: *porpidia*-type

From the Editor-in-Chief

Mycotaxon welcomes two final editorial advisors—Our heretofore understaffed advisory board successfully completed its first task for 2019 by nominating and electing two new members to bring itself up to full advisory strength. We are extremely pleased to welcome Elaine Malosso and Xinli Wei, who join Chair Brandon Matheny, Karen Hansen, Else Vellinga, and Todd Osmundson on the journal's masthead (p. ii).

Profa. Elaine Malosso, currently with UFPE (Universidade Federal de Pernambuco) in Recife, Brazil, received her Ph.D. in Molecular Microbial Ecology from the University of Newcastle upon Tyne (England) in 2003. Fluent in English, Portuguese, and Spanish, Elaine has both co-authored and reviewed numerous papers on hyphomycetes for Mycotaxon and is also interested in fungal diversity, decomposition, molecular phylogenetic analyses, soils, fresh water, and arbuscular mycorrhizal fungi.

Prof. Xinli Wei, who served as a postdoctoral fellow at Sunchon National University, South Korea, during 2006–2007 and Visiting Scholar at Chicago's Field Museum in Illinois (USA) during 2016–2017, began her study of lichens in 2000. As professor at the State Key Laboratory of Mycology & Lichenology at the Chinese Academy of Sciences in Beijing, she also served as Chief Editor of the Lichen Flora of China (English version). Xinli is especially interested in the taxonomy and biogeography of *Hypogymnia,* and has also contributed to numerous papers for Mycotaxon.

Mycotaxon 134(3) contains 20 papers by 78 authors (representing 12 countries) and examined by 34 pre-submission expert reviewers as well as by the Nomenclature Editor and Editor-in-Chief.

The 2019 July–September Mycotaxon proposes two new genera (*Morganjonesia* from China and *Ramomarthamyces* from New Zealand & the Cook Islands) plus 19 newly described species representing *Annulohypoxylon, Botryosphaeria, Coenogonium, Pleurotheciopsis, Repetophragma,* and *Septobasidium* from China; *Beltraniomyces* & *Glabrocyphella* from Brazil; *Cystostereum* from India; *Marthamyces* & *Ramomarthamyces* from New Zealand & the Cook Islands; and *Tretoheliocephala* from Thailand. We also publish seven new combinations in *Heteroscypha, Marthamyces, Morganjonesia,* and *Ramomarthamyces* and present a newly established synonymy for *Erysiphe sedi* (accompanied by neotypification of *Oidium kalanchoes*).

New species range extensions are reported for [ascomycetes] *Pseudopyricularia cyperi* in Iran; [basidiomycetes] *Amanita subjunquillea* and its ectomycorrhizae in Pakistan, *Limacella* for the first time in Thailand, and the cyphelloid fungus *Rectipilus natalensis* in Brazil; and in China [lichens] *Acarospora* & *Psora* and *Coenogonium* (accompanied by a key to all species in the country); and [myxomycetes] dictyostelid social amoebae.

This issue is rounded out by the announcement of a new mycobiota covering macrofungal diversity in Yushan and Else Vellinga's reviews of three new substantial field identification guides.

Warm regards,

Lorelei L. Norvell (*Editor-in-Chief*)
28 September 2019

2019 Mycotaxon submission procedure

Prospective Mycotaxon authors should download the Mycotaxon 2019 guide, review & submission forms, and Mycotaxon sample manuscript by clicking the 'file download page' link on our Instructions to Authors page before preparing their manuscript. This page briefly summarizes our '4-step' submission process.

1—Peer review: Authors first contact peer reviewers (two for journal papers; three for mycobiota/fungae) before sending them formatted text & illustration files and the appropriate 2019 Mycotaxon journal or weblist reviewer comment form. Experts return revisions & comments to both the *Editor-in-Chief* <editor@mycotaxon.com> and authors. All co-authors must correct and *proof-read* their files before submitting them to the *Nomenclature Editor*.

2—Nomenclatural review: Authors email all **error-free** text & illustration files to the *Nomenclature Editor* <PennycookS@LandcareResearch.co.nz>. Place **first author surname** + **genus** + 'Mycotaxon' on the subject line, and (required) attach a completed submission form. The Nomenclature Editor will (i) immediately assign the accession number and (ii) after a few weeks return his notes and suggested revisions to the author(s) and *Editor-in-Chief*.

3—Final submission: All coauthors thoroughly revise and proof-read files to prepare error-free text and images ready for immediate publication. Poorly formatted copy will be rejected or returned for revision. They email the final manuscript to the *Editor-in-Chief* <editor@mycotaxon.com>, adding the **accession number** to the message and **all** files, which include a **(i)** revised 2019 submission form, all **(ii)** text files and **(iii)** jpg images, and **(iv)** FN, IF, or MB identifier verifications for each new name or typification. The *Editor-in-Chief* acknowledges submissions within two weeks of final submission but requests authors to wait at least 14 days before sending a follow-up query (without attachments).

4—Final editorial review & publication: The *Editor-in-Chief* conducts a final grammatical and scientific review and returns her editorial revisions to all expert reviewers and coauthors for final author approval. Author-approved files are placed in the publication queue.

The PDF proof and bibliographic & nomenclatural index entries are sent to all coauthors for final inspection. After PDF processing, the *Editor-in-Chief* corrects only PDF editorial/conversion and index entry errors; corrections of all other errors are listed in the Errata of a subsequent issue for no charge. Authors will pay fees for mycobiota uploads, optional open access, and correction of major author errors to the *Business Manager* <subscriptions@mycotaxon.com> at this time.

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Amanita subjunquillea and its ectomycorrhizal association, reported as new for Pakistan

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Abstract—*Amanita subjunquillea* and its ectomycorrhizal association are reported for the first time from moist temperate Himalayan forests of Pakistan. The sample was studied based on morphological characters and nucleotide sequence analyses of the ITS region generated from basidiomata and ectomycorrhizal roots of *Quercus floribunda*. Our collection differs from the type in its dark orange pileus disc and pale yellow margins. Remaining morphological and molecular data are consistent with previously reported specimens. This represents the first report of *A. subjunquillea* from Pakistan.

Keywords—*Amanitaceae, Basidiomycota, Phalloideae,* ribosomal DNA, taxonomy

Introduction

Amanita Pers. (*Amanitaceae, Agaricales, Basidiomycota*) is a large genus comprising about 1000 described species that are important economically and ecologically (Bas 2000, Tulloss 2005, Yang 2005, Kirk & al. 2008, Li & al. 2015, Zhang & al. 2015, Cui & al. 2018, Yang & al. 2018). *Amanita* contains both edible and poisonous species, and some species form ectomycorrhizal associations with vascular plants, which play a key role in maintaining healthy ecosystems (Zhang & al. 2004, 2010; Thongbai & al. 2016; Cui & al. 2018; Yang & al. 2018). Poisonous *Amanita* species are classified mostly in *A.* sect. *Phalloideae* (Fr.) Konrad & Maublanc, which is characterized by the absence of striation and

lack of appendiculate pileus and the possession of attenuate lamellulae, an annulus, a stipe with a bulbous base and limbate shaped volva, and amyloid basidiospores (Corner & Bas 1962, Bas 1969, Yang 2005, Cai & al. 2016, Cui & al. 2018). *Amanita subjunquillea,* also known as the East Asian death cap, is a poisonous mushroom broadly distributed in diverse habitats in China, India, Japan, and South Korea (Bhatt & al. 2003, 2007; Yang 2005; Zhang & al. 2010; Cui & al. 2018). Symptoms of *A. subjunquillea* poisonings are gastrointestinal in nature and similar to *A. phalloides,* and ingestion can result in death (Rho & al. 2000, Kim & al. 2008).

A total of 24 species of *Amanita* have been reported from Pakistan, but it is estimated that the true number of *Amanita* from Pakistan could be above 50 (Kiran & al. 2018, Jabeen & al. 2019, Saba & al. 2019). Many collections of *Amanita* have been identified locally based on morphological features; however, such identifications are not reliable because some poisonous and edible mushrooms are morphologically similar. The Korea Forest Service reported the occurrence of twenty-three fatal mushroom poisonings in Korea during 2004–13 (Cho & al. 2015; www.forest.go.kr/). Such cases also occur every year in rural areas of Pakistan, especially in hilly areas of Swat, Khyber Pakhtunkhwa. The aim of this study was to confirm our collection of *A. subjunquillea* from Buner District as a new record for Pakistan using morphological, molecular and phylogenetic data.

Materials & methods

Sampling site

Collections were made at Bottle Green Mountains, Gokand Valley, Buner District, Khyber Pakhtunkhwa, Pakistan, at 3183 m a.s.l. The climate of Gokand is subtropical at lower elevations and temperate above. This area is covered by mixed forests of conifers (*Pinus roxburghii* Sarg., *P. wallichiana* A. B. Jacks.) and broadleaf trees (*Populus ciliata* Wall. ex Royle, *Q. floribunda* Lindl. ex A. Camus [= *"Q. dilatata"* Royle], *Q. oblongata* D. Don [= *Q. incana* Roxb.], *Zanthoxylum armatum* DC., and *Olea europaea* subsp. *cuspidata* (Wall. & G. Don) Cif. [= *O. ferruginea* Royle]). Blue pine (*P. wallichiana*) and chir pine (*P. roxburghii*) forests predominate (Khan & al. 2003).

The area was sampled during rainy seasons in July and August in 2017. Specimens were tagged and photographed on site. Morphological characters were recorded from fresh fruiting bodies in field, with colors coded according to Munsell Soil Color Charts (1975). Specimens were then dried using a fan heater and placed in small zip-lock bags for long-term preservation.

Sampling, Isolation, and morphological characterization of ectomycorrhizal roots

Soil cores (15 cm^3) were dug from moist temperate oak forests close enough to *Quercus floribunda* tree trunks to ensure that they contained *Quercus* roots. Twenty to twenty-five soil cores were taken from every sampling site and stored in polythene bags to prevent evaporation. In the laboratory, each soil core was drenched in water up to 1–2 hours and then held over a 2 mm sieve beneath running water to detach roots from soil particles. Ectomycorrhizal roots were sorted into morphotypes using a Meiji Techno EMZ-5TR stereomicroscope. The morphotypes were then kept in distilled water in McCartney bottles, with replicates reserved in 2% CTAB buffer at 8°C for molecular analysis. The material was deposited in Lahore Herbarium, Department of Botany, University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan (LAH).

Morphological analyses of basidiomata

For microscopic studies, tissues of pileus, gills, annulus, stipe, and volva were mounted in 5% KOH, stained with 1% aqueous Congo red (w/v), and observed under a Labomed light microscope. Basidiospore dimensions include length and width ranges (with parenthetical extreme values), range of Q coefficients (L/W), mean length and width ($L_m \times W_m$), and mean Q value (Q_m). The collection was vouchered and deposited in Lahore Herbarium, Department of Botany, University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan (LAH).

DNA extraction, amplification, and sequencing

DNA was extracted using a modified CTAB method (Bruns 1995). The nuclear ribosomal internal transcribed spacer (ITS) locus was amplified using the fungal-specific ITS1F primer (5-CTTGGTCATTTAGAGGAAGTAA-3; Gardes & Bruns 1993) and the eukaryotic ITS4 primer (5-TCCTCCGCTTATTGATATGC-3; White & al. 1990). The amplified products were sent to Macrogen Inc. in Korea for purification and sequencing.

For identification of ectomycorrhiza, DNA was extracted using the Qiagen DNeasy Plant Mini Kit, and the ITS was amplified using the ITS1F/ITS4 primers. Amplicons obtained from ectomycorrhizal roots were purified with Exonuclease I and Shrimp Alkaline Phosphatase enzymes (Werle & al. 1994) and sequenced at the University of Florida Interdisciplinary Center for Biotechnology Research (www.biotech.ufl.edu/). Sequences were BLAST searched at NCBI (blast.ncbi.nlm.nih.gov/Blast.cgi), and closely related *Amanita* sequences were retrieved from GenBank. All the sequences were assembled in BioEdit (Hall 1999) and trimmed to facilitate alignment. A maximum likelihood tree was inferred for the ITS alignment using RAxML-HPC2 v 8.1.11 (Stamatakis 2014) with a GTRCAT nucleotide substitution model. Rapid bootstrapping was performed with 1000 bootstrap iterations. All phylogenetic analyses were performed on the CIPRES Science Gateway v3.1 (Miller & al. 2010). The phylogeny from ML analysis was displayed with FigTree v1.4.2 (tree.bio.ed.ac.uk/software/figtree/) and then edited in Adobe Illustrator. All newly generated sequences were submitted to GenBank.

Fig. 1. *Amanita subjunquillea* (LAH35854).
Basidiomata. Scale bars: A = 0.79 cm; B = 1.17 cm; C = 1.02 cm.

Taxonomy

Amanita subjunquillea S. Imai, Bot. Mag., Tokyo 47: 424 (1933) FIGS 1, 2

PILEUS 60–70 mm diam, plano-convex with a slightly depressed disc and slightly uplifted margin, dark orange (10YR9/2) at disc, becoming light brown (5Y 9/4) toward margin; context white (5Y9/2) when cut. LAMELLAE free, close, entire, margins whitish (10Y9/2) to pale yellow (10Y 9/4). LAMELLULAE truncated, abundant, irregularly distributed. STIPE 120–130 × 5–15 mm, cylindrical, slightly tapering upwards, whitish (5Y9/2) at the base and pale yellowish (5Y9/4) toward the apex, covered by pale yellowish (5Y9/4) fibrillose squamules. ANNULUS superior, membranous, persistent, pendant, whitish (5Y 9/2) to pale yellow (5Y 9/4). VOLVA limbate, membranous, white.

BASIDIOSPORES (3.8–)4.3–5.7(–6.1) × (3.8–)4.1–5.2(–5.6) µm, Q = 1–1.2(–1.3), $L_m \times W_m = 5.1 \times 4.6$ µm, $Q_m = 1.1$, globose to subglobose, hyaline in 5% KOH, amyloid in Melzer's reagent, thin-walled, smooth, monoguttulate; apiculus 0.6–1 µm long. BASIDIA 20–27 × 8–9 µm, 2–4-spored, thin-walled, hyaline, narrowly clavate to clavate; sterigmata 1–2 µm long. PILEIPELLIS hyphae 4–6 µm diam, branched, filamentous, septate, ellipsoid to subcylindrical, hyaline. Volva cells globose, ovoid to broadly lageniform 7–35 µm diam, 19–68 µm long; filamentous hyphae 3.1–4.5 µm diam. STIPITIPELLIS hyphae 12–16 µm diam, septate, unbranched, thin-walled, hyaline in 5% KOH. PARTIAL VEIL ELEMENTS 34–55 × 10–21 µm, ellipsoid to clavate intermixed with short septate filaments 1–2 µm diam. CLAMP CONNECTIONS absent throughout.

MATERIAL EXAMINED: **PAKISTAN. KHYBER PAKHTUNKHWA PROVINCE, Buner District**, Gokand Valley, Bottle Green Mountains, 3183 m a.s.l., under *Quercus floribunda* [= "*Q. dilatata*" Royle], solitary, 13 August 2017, Muhammad Ishaq IB124 (LAH-35854; GenBank MH620472).

HABITAT: Solitary on soil under *Quercus floribunda.*

Ectomycorrhizal morphology FIG. 3

MYCORRHIZAL SYSTEM monopodial pinnate, 20–45 mm, 0.7–1 mm thick, profusely branched, surface smooth, light brown (5YR8/4), older parts dark reddish brown (5YR3/4). Unramified ends slightly straight to (infrequently) bent, cylindrical. Mantle brown (5YR8/5), not translucent. OUTER MANTLE HYPHAE 2.7–3.4 µm diam, thin-walled, septate, branched, cells similar in size to inner mantle hyphae, sub-cylindrical to ellipsoid, end cells obtuse, no clamp connections. INNER MANTLE HYPHAE 2.4–3.5 µm diam, thin-walled, septate,

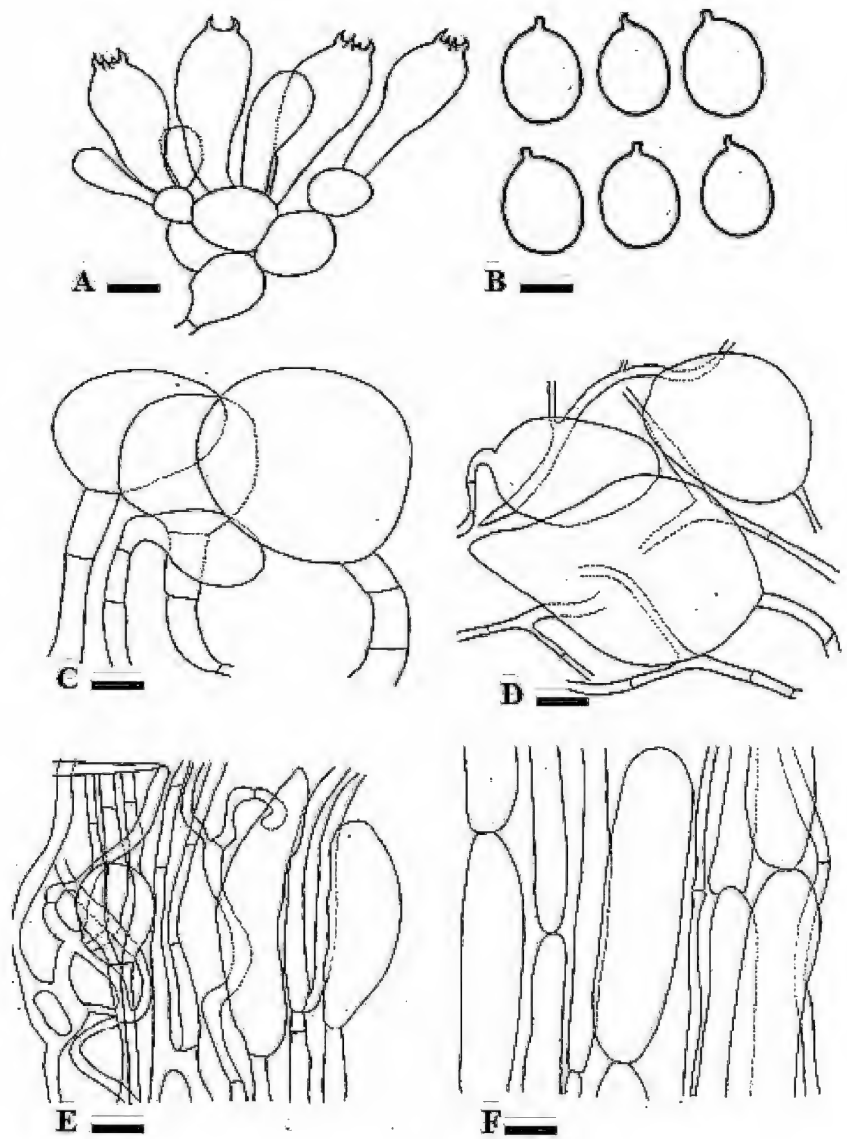

Fig. 2. *Amanita subjunquillea* (LAH35854). A. Basidia; B. Basidiospore; C. Partial veil elements; D. Volva; E. Pileipellis; F. Stipitipellis. Scale bars: A = 7.5 µm; B = 3 µm; C, D = 7 µm; E = 4.5 µm; F = 1 µm.

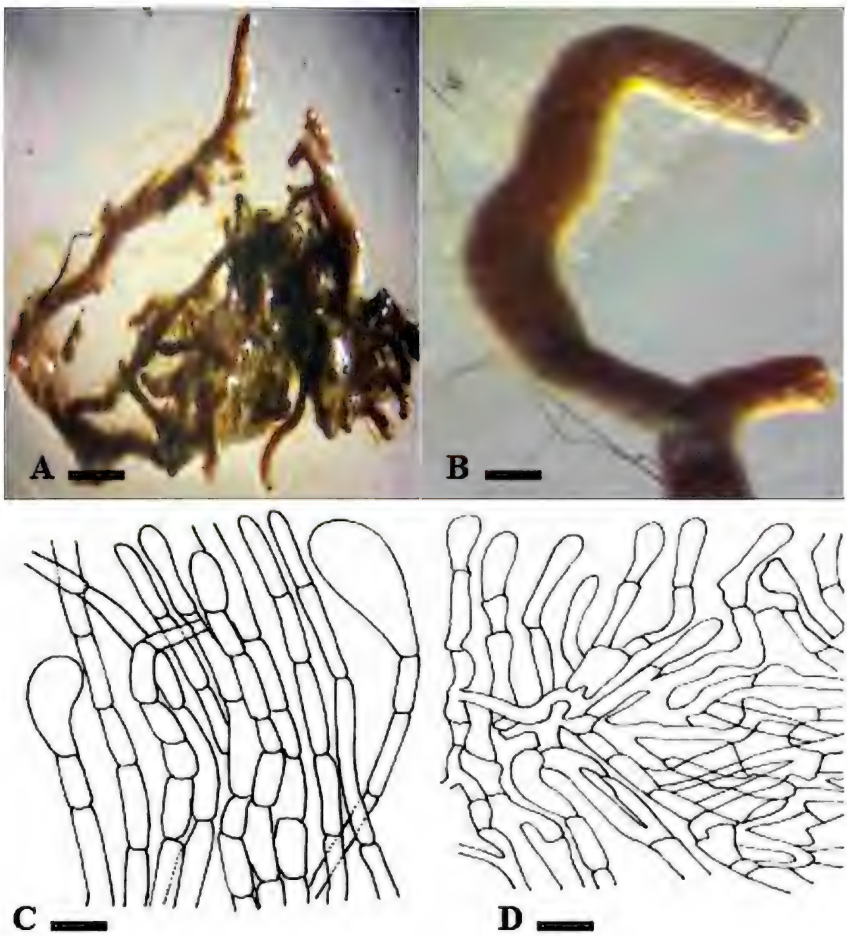

Fig. 3. *Amanita subjunquillea/Quercus floribunda* mycorrhizae (LAH-EM101, LAH-EM102). A., B. Ectomycorrhizal roots; C. Inner mantle layer cells; D. Outer mantle layer cells. Scale bars: A = 1.91 mm; B = 0.54 mm; C = 4.5 µm; D = 10.2µm.

unbranched, narrowly clavate to clavate, 6–11 µm long, end cells obtuse, cystidia infrequent. Emanating hyphae numerous, white. Rhizomorphs white (2.5R9/2), thick, frequent, abundant.

Material examined: **PAKISTAN. Khyber Pakhtunkhwa Province, Shangla/ Swat boundary**, Toa, 2100 m a.s.l, associated with roots of *Quercus floribunda*, 15

July 2015, Arooj Naseer & Abdul Nasir Khalid ANT210 (LAH-EM101; GenBank MH998629); ANT211 (LAH-EM102; GenBank MH998628); ANT212 (LAH-EM103; GenBank, MH998627).

Phylogenetic results

FIG. 4

The aligned ITS dataset, including sequences retrieved from GenBank, comprised 30 nucleotide sequences. Of the 665 characters in the final dataset, 275 were conserved, 363 were variable and parsimony-uninformative, and 228 were parsimony-informative. Our ML tree contains three sections: *Amanita* sect. *Validae, A.* sect. *Amanita*, and *A.* sect. *Phalloideae*. The

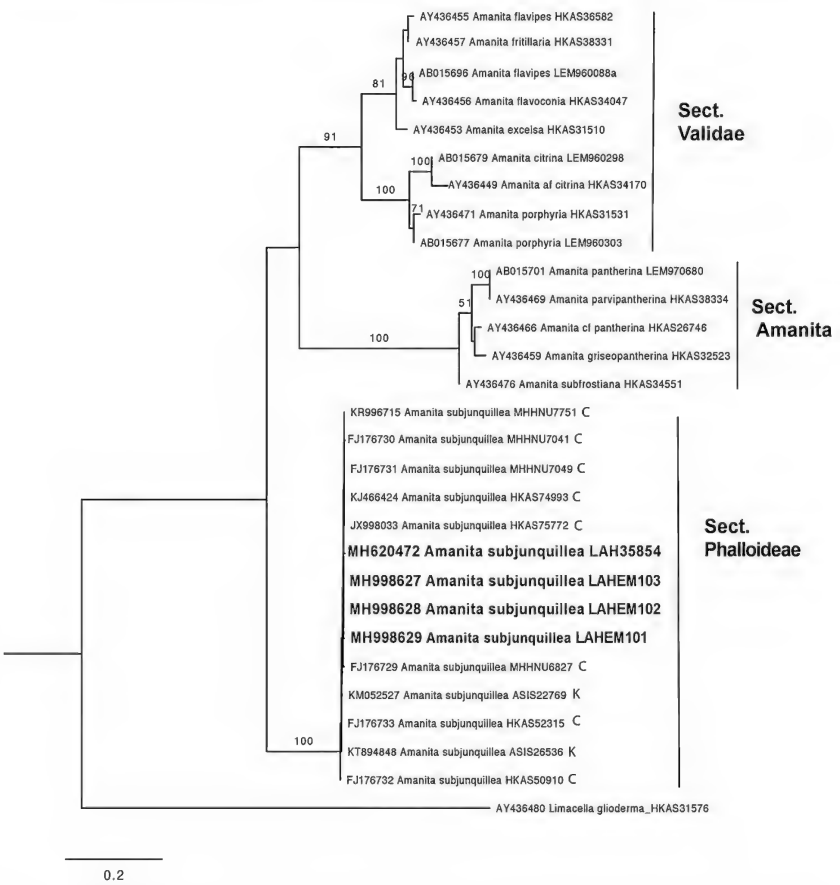

FIG. 4. Molecular phylogenetic reconstruction of *Amanita* spp. based on ITS sequences. The best scoring ML tree (–lnL = 1591.4482) is shown. Only bootstrap values >50 are shown. *Amanita subjunquillea* sequences from China are annotated as [C] and those from Korea as [K].

sequences from our Pakistani specimen and ectomycorrhizal roots, grouped within *A.* sect. *Phalloideae* with previously generated sequences of *A. subjunquillea* from China and South Korea.

Comparison of the ITS sequences revealed 19 polymorphic positions among different collections of *A. subjunquillea* from Pakistan, China, and Korea. The Pakistani sequence contains eleven polymorphic positions (at positions 2, 7, 32, 35, 107, 204, 504, 507, 553, 648, and 667), with most nucleotides at these allelic positions resembling Chinese samples. However, one Chinese sample is closer to the Korean specimen KT894848. Maximum nucleotide differences were observed in Korean sample KM052527, with seven positions differing from all other collections, including Korean sample KT894848. It is possible that the KM052527 ITS sequence needed additional purification, but more sequences are required to verify these seven nucleotide differences.

Discussion

Amanita subjunquillea is a deadly poisonous mushroom distinguished by a brownish yellow to mustard yellow pileus, non-appendiculate margins, and a subglobose to subclavate to turnip-shaped basal bulb (Yang 1997, 2005; Cai & al. 2016; Cui & al. 2018).

Macroscopic and microscopic details of the examined specimens match the protologue description of *A. subjunquillea* (Imai 1933), except for pileus coloration patterns. The pileus color of the Pakistani specimen is dark orange at the disc and pale yellow toward the margin, while the type specimen is described with the pileus darker at the center and brownish yellow, dirty citrine yellow, or mustard yellow toward the margin. This is the only macroscopic difference separating our collection from the type; the nearly cylindrical stipe that tapers slightly upward and is covered with yellowish fibrillose scales matches the type description. The spore and basidial shapes are similar among all collections, but the basidia and spore sizes are smaller in our specimen compared with Indian and East Asian specimens. Clamp connections are absent in all specimens.

Our phylogenetic analysis clustered ITS sequences from our Pakistani collection and ectomycorrhizal roots in *A.* sect. *Phalloideae* with ten other sequences belonging to *A. subjunquillea*. We found some variation among the Chinese, Korean, and Pakistani nucleotides; nucleotide differences within same species from different localities of China were also observed by Zhang & al. (2010). The type collection was sampled under warm temperate

conditions in Tokyo whereas our sampling site lies in a moist temperate region. These environmental differences can affect gene function so that same species collected from different geographic regions may show minor variation in both morphological and molecular characters.

Amanita subjunquillea is endemic to East Asia (Zhang & al. 2010). This is the first published report of its ectomycorrhizal association with *Quercus floribunda* based on morphological, anatomical, and phylogenetic data. *Amanita subjunquillea* has previously been reported from Japan, Korea, India, and China, to which we now add Pakistan.

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New records of dictyostelid social amoebae from China

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Abstract—Two species of dictyostelids (*Dictyostelium aureocephalum* and *Heterostelium filamentosum*) new to China were isolated from samples of forest soils; and a second Chinese record of *Coremiostelium polycephalum* (previously recorded from Taiwan) was also isolated. Descriptions and illustrations based on these isolates are provided.

Key words—*Acytosteliaceae*, *Dictyosteliaceae*, *Dictyostelida*, *Mycetozoa*, taxonomy

Introduction

Dictyostelid cellular slime molds (dictyostelids), with both animal-like (protozoan) and fungus-like characteristics, are the second largest group of slime molds. These organisms play a role in maintaining the balance that exists between bacteria and other organisms in soils (Raper 1984). The original system that placed dictyostelids in genera based on morphology was revised by Sheikh & al. (2018), who proposed a new classification based on unique 18S rRNA sequence signatures.

In sampling from Chinese soils, two dictyostelid species, *Dictyostelium aureocephalum* and *Heterostelium filamentosum*, were recorded as new from China, and *Coremiostelium polycephalum*, previously isolated from Taiwan, was recorded as new from Fujian Province. Descriptions and illustrations based on these newly recovered isolates are provided.

Materials & methods

Samples used for dictyostelid isolations were collected from Shandong Province, Fujian Province, and Yunnan Province, China, in 2012 and 2016. Each sample

consisted of 30–50 g of soil that was placed in a sterile whirl-pack plastic bag. Each sample bag was numbered and the sample itself preserved at 4 °C in the herbarium of the Mycological Institute of Jilin Agricultural University, Changchun, China (HMJAU). Isolation methods followed Cavender & Raper (1965), with some minor modifications outlined by Liu & al. (2019). Isolates were identified using the descriptions in Raper (1984) and the new classification system proposed by Sheikh & al. (2018). The characteristic stages in the life cycle, including cell aggregation and formation of pseudoplasmodia and sorocarps, were observed under a Zeiss Axio Zoom V16 dissecting microscope with a 1.5× objective and a 10× ocular. Slides with sorocarps were prepared with water as the mounting medium. Spores, sorophores, and sorocarps were observed on the slides and measured using a Zeiss Axio Imager A2 light microscope with 10× ocular and 10, 40, and 100× (oil) objectives. Photographs were taken with Zeiss Axiocam 506 color microscope camera. Vouchers were conserved in the Herbarium of the Mycological Institute of Jilin Agricultural University, Changchun, China (HMJAU).

Taxonomy

Dictyostelium aureocephalum H. Hagiw.,
Bull. Nat. Sci. Mus., Tokyo, B 17(3): 103. 1991. PLATE 1a–g

When cultured at 23 °C on non-nutrient agar with *Escherichia coli*, sorocarps gregarious, solitary, prostrate, phototropic, normally 0.7–2.6 mm. Sorophores colorless, sinuose, with hook-like structures if prostrate, tapering from conical bases to clavate tips, basal disks small. Sori yellow, globose, commonly 70–210 µm in diam. Spores hyaline, elliptical, 5.7–8.0 × 2.9–3.9 µm, without polar granules. Aggregations with radiate streams.

SPECIMEN EXAMINED: **CHINA**, **YUNNAN PROVINCE**, **Lijiang**, Yulong Mountains, from soil (S5204) collected 22 Oct. 2016 in a mixed forest, isolated 2016, P. Liu & al. (HMJAU MR228).

COMMENTS—*Dictyostelium aureocephalum* was first isolated from a sample collected from the humus layer of a scrub and meadow in the alpine region of Nepal (Hagiwara 1991). This species is characterized by its yellow sori. It has PG– spores and somewhat smaller sorocarps, features that distinguish it from other dictyostelids with yellowish sori.

Heterostelium filamentosum (F. Traub & al.) S. Baldauf, S. Sheikh & Thulin,
Protist 169(1): 11. 2018. PLATE 1h–l

When cultured at 23 °C on non-nutrient agar with *E. coli*, sorocarps white, erect to semi-erect, with whorls of both primary and secondary branches, the terminal segments always elongate. Sorophores colorless, tapering from bases to tips. Terminal sori always small, white, globose, commonly 30–80 µm diam.

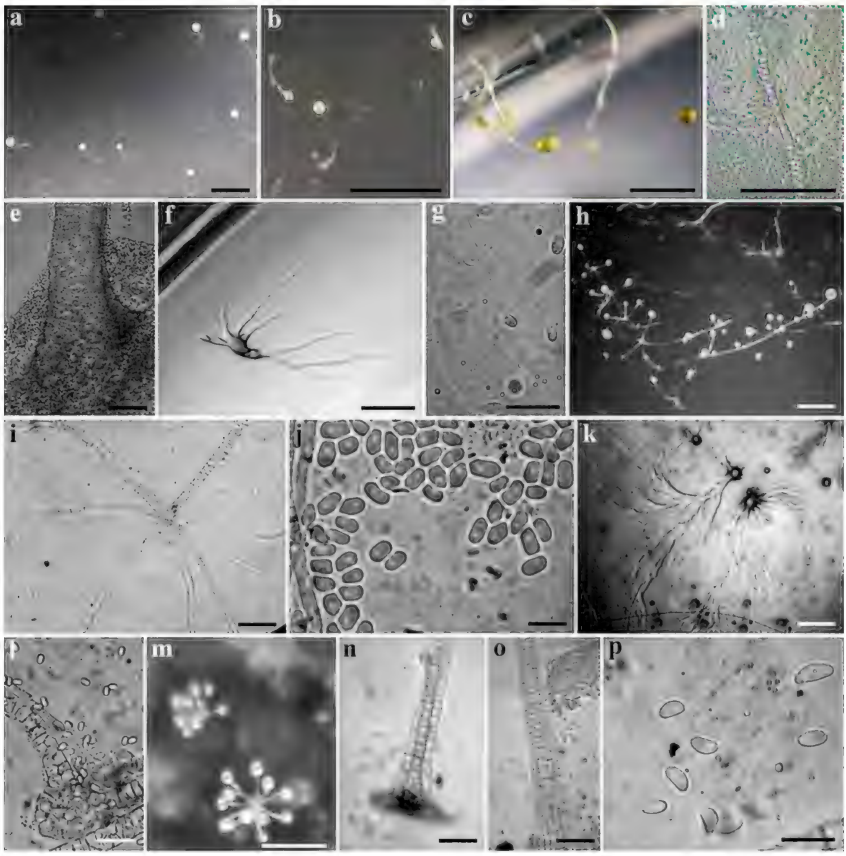

Plate 1. ***Dictyostelium aureocephalum:*** a–c. Sorocarps; d. Sorophore tip; e. Sorophore base; f. Aggregation; g. Spores. ***Heterostelium filamentosum:*** h. Sorocarps; i. Sorophore branches; j. Spores; k. Aggregation; l. Sorophore base. ***Coremiostelium polycephalum:*** m. Sorocarps; n. Sorophore base; o. Sorophore; p. Spores. Scale bars: a, b = 2 mm; c, f, h, k, m = 1 mm; d = 100 μm; e = 50 μm; g, i, n, o = 20 μm; j, l, p = 10 μm.

Lateral sori white, globose, commonly 45–160 μm diam. Spores elliptical to oval, mostly 7.5–11 × 3.5–5 μm, with unconsolidated polar granules. Aggregations radiate.

Specimen examined: **CHINA**, **Shandong Province**, **Jinan**, Jinxiang Mountain, from soil (S2832) collected 9 Aug. 2012 in a broadleaf forest, isolated 2013, P. Liu & al. (HMJAU MR182).

Comments—*Heterostelium filamentosum* was originally isolated and reported as widespread in Switzerland (Traub & al. 1981). It has also been found in

other countries such as the United States, Japan (Raper 1984; Hagiwara 1989, 2008), and China (this study). This species is characterized by its large spores, secondary branches, and elongation of branches.

Coremiostelium polycephalum (Raper) S. Baldauf, S. Sheikh, Thulin & Spiegel, Protist 169(1): 24. 2018. PLATE 1m–p

When cultured at 23 °C on non-nutrient agar with *E. coli*, sorocarps white, erect, solitary, commonly less than 1 mm tall, typically clustered to form coremiform sorocarps, normally consisting 2–10 branches per cluster. Sorophores tapering from bases to tips. Sori white or hyaline, globose, 45–85 μm diam. Spores elliptical, usually 6.0–7.5 × 3.0–3.5 μm, with unconsolidated granules. Aggregations radiate.

SPECIMEN EXAMINED: **CHINA, FUJIAN PROVINCE, Fuzhou,** from soil (S2052) collected 24 Mar. 2012 in a coniferous forest, isolated 2012, P. Liu & al. (HMJAU MR177).

COMMENTS—The type of *Coremiostelium polycephalum* was isolated from the soil of a mixed forest in South Carolina in the United States (Raper 1984; Hagiwara 1989). It is a worldwide species which has been found in Africa, America, Asia, and Europe. However, this is only the second report from China. Both of these two localities (Fujian Province and Taiwan) are located in subtropical China, so this species seems to prefer warmer habitats. This species has small clustered sorocarps developed in a coremium-like manner, a feature which allows it to be distinguished from other dictyostelids.

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Annulohypoxylon bawanglingense, A. diaoluoshanense, A. guangxiense, and *A. sichuanense* spp. nov. and new records from China

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Abstract—Four new species—*Annulohypoxylon bawanglingense, A. diaoluoshanense, A. guangxiense,* and *A. sichuanense*—are described, and *A. maeteangense* and *A. substygium* are recorded as new to China.

Key words—*Ascomycota,* pyrenomycetous fungi, taxonomy, *Hypoxylaceae, Xylariales*

Introduction

We describe four new species of *Annulohypoxylon* and two new *Annulohypoxylon* records from China. These specimens are conserved in the Herbarium Mycologicum Academiae Sinicae, Beijing, China (HMAS).

Materials & methods

The specimens were examined using a Motic SMZ-168 stereomicroscope. Microscopic features of asci and ascospores were described from slide preparations mounted in water and Melzer's reagent, and measurements were made from 20 ascospores using a Zeiss Axioskop 2 plus compound microscope. Stromata were photographed using a Sony NEX-7 digital camera.

Taxonomy

Annulohypoxylon bawanglingense Wei Li bis & L. Guo, **sp. nov.** Figs 1–3

FN 570628

Differs from *Annulohypoxylon moriforme* by its larger ascospores, and from *A. microdisicum* by its larger disc on the ostiole.

Type: China, Hainan, Changjiang, Bawangling, alt. 490 m, on the wood of the *Adenanthera microsperma* Teijsm. & Binn. (*Leguminosae*), 17.II.2017, L. Guo 12112 (**Holotype**, HMAS 248019).

Etymology: The epithet refers to the type locality, Bawangling.

Stromata pulvinate to effused-pulvinate, with conspicuous perithecial mounds, up to ¼ exposed, 0.2–17 × 0.15–3.5 cm, 0.9–1.5 mm thick; surface brownish black; blackish brown granules immediately beneath surface, shiny, with KOH-extractable greenish olivaceous pigment; the tissue below the perithecial layer inconspicuous, black. Perithecia subspherical to obovate, 0.35–0.5 mm diam. Ostioles papillate, encircled with a *truncatum*-type disc, 0.35–0.5 mm diameter. Asci 119–170 µm long overall, the spore-bearing parts 80–100 × 4–5 µm above 40–70 µm long stipes; apical ring bluing in Melzer's iodine reagent, discoid, 1–1.5 µm high, 1.5–2 µm broad. Ascospores brown, unicellular, ellipsoid-inequilateral, with narrowly rounded ends, 8–11 × 3.5–4 µm, with straight germ slit spore-length; perispore dehiscent in 10% KOH, smooth, epispore smooth.

Comments: *Annulohypoxylon bawanglingense* is similar to *A. moriforme* (Henn.) Y.M. Ju & al., which differs in its smaller (6–9 × 2.5–4 µm) spores (Ju & Rogers 1996). The new species resembles *A. microdiscum* (Y.M. Ju & J.D. Rogers) Sir & Kuhnert, which differs in its smaller (0.1–0.17 mm diam) discs surrounding the ostioles (Kuhnert & al. 2017).

Annulohypoxylon diaoluoshanense Wei Li bis & L. Guo, **sp. nov.** Figs 4–6

FN 570630

Differs from *Annulohypoxylon macrodiscum* by its thicker stromata.

Type: China, Hainan, Diaoluoshan, on wood, 26.IX.1958, RY. Zheng & al. 227 (**Holotype**, HMAS 29644).

Etymology: The epithet refers to the type locality, Diaoluoshan.

Stromata hemispherical, with inconspicuous to conspicuous perithecial mounds, 1.2–4 × 1–3.3 cm, 4–10 mm thick; surface blackish brown, blackish brown granules immediately beneath surface, with KOH-extractable greenish olivaceous pigment; the tissue below the perithecial layer blackish brown, conspicuous, 3–7 mm thick. Perithecia spherical or obovate, 0.8–1.2 mm diam.

Figs 1–9. ***Annulohypoxylon bawanglingense*** (HMAS 248019, holotype). 1. Stromata on wood; 2, 3. Ascospores. ***Annulohypoxylon diaoluoshanense*** (HMAS 29644, holotype). 4. Stromata on wood; 5, 6. Ascospores. ***Annulohypoxylon guangxiense*** (HMAS 33768, holotype). 7. Stromata on wood; 8, 9. Ascospores.

1
2
10 um
3
10 um
4
5
10 um
6
10 um
7
8
10 um
9
10 um

Ostioles conical-papillate, encircled with a *truncatum*-type disc, 0.5–0.8 mm diam. Asci not seen. Ascospores dark brown, unicellular, ellipsoid-inequilateral, with broadly rounded ends, 8–11.5 × 4–5.5 μm, with straight germ slit spore-length; perispore dehiscent in 10% KOH, smooth, epispore smooth.

Comments: *Annulohypoxylon diaoluoshanense* is similar to *A. macrodiscum* Jad. Pereira & al., which differs in its thinner (0.8–1 mm thick) stroma and thinner tissue (0.3–0.5 mm thick) below the perithecial layer (Pereira & al. 2010).

Annulohypoxylon guangxiense Wei Li bis & L. Guo, **sp. nov.** Figs 7–9

FN 570633

Differs from *Annulohypoxylon archeri* by its tissues without apparent KOH-extractable pigments and its perispore indehiscent in 10% KOH.

Type: China, Guangxi, Donglan, on wood, 20.I.1958, LW. Xu 822 (**Holotype**, HMAS 33768).

Etymology: The epithet refers to the type locality, Guangxi Province.

Stromata pulvinate, with inconspicuous perithecial mounds; 1–4 × 0.6–1.8 cm, 0.5–1 mm thick; surface blackish brown, blackish brown granules immediately beneath surface and lacking KOH-extractable pigments; the tissue below the perithecial layer inconspicuous. Perithecia spherical, 0.4–0.5 mm diam. Ostioles papillate, encircled with a *truncatum*-type disc, 0.1–0.2 mm diam. Asci not seen. Ascospores brown, unicellular, ellipsoid-inequilateral, with narrowly rounded ends, 8–12.5 × 3–5 μm, with straight germ slit spore-length; perispore indehiscent in 10% KOH, smooth, epispore smooth.

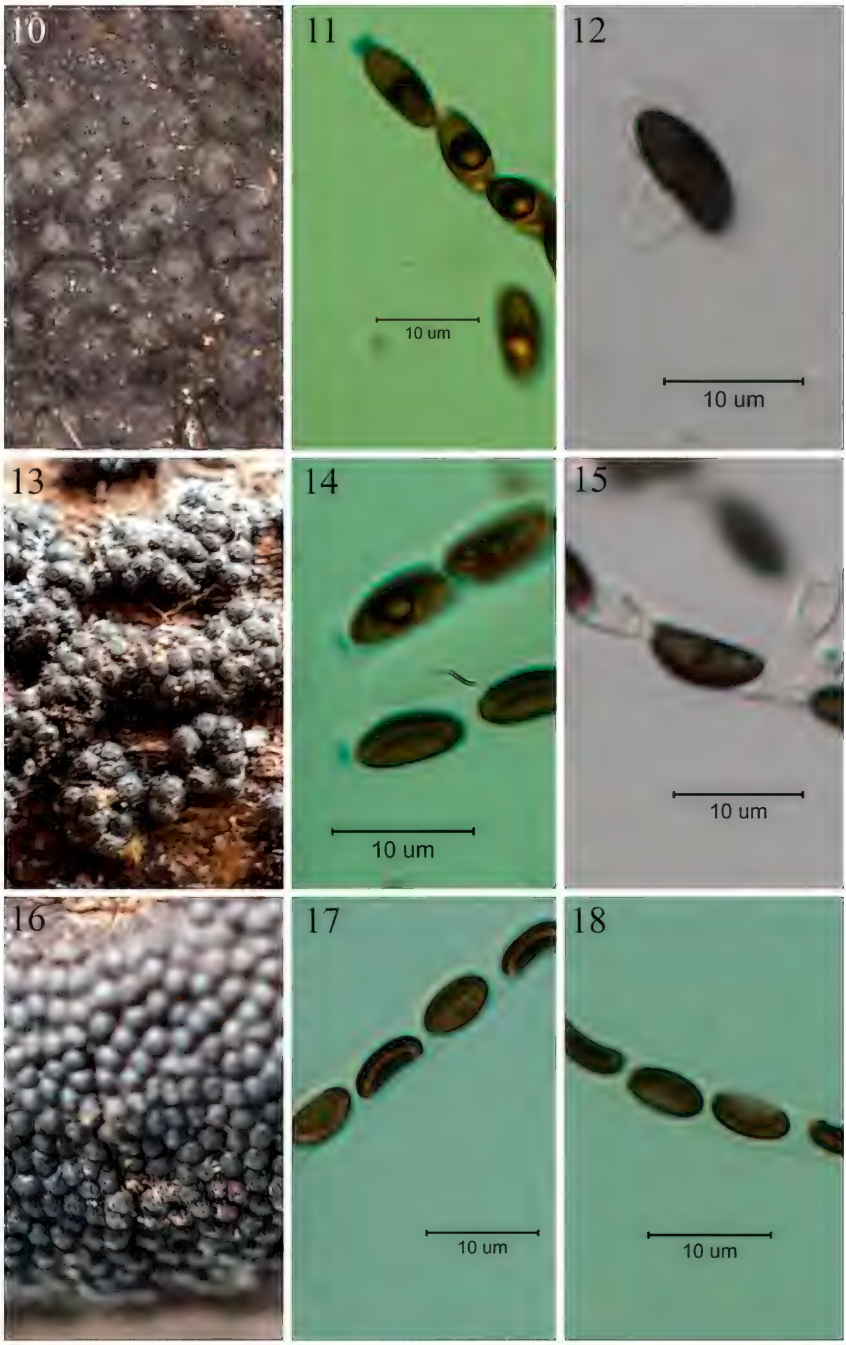
Comments: *Annulohypoxylon guangxiense* is similar to *A. archeri* (Berk.) Y.M. Ju & al, which differs in its tissues with KOH-extractable greenish olivaceous pigments and perispore dehiscent in 10% KOH (Ju & Rogers 1996).

Annulohypoxylon sichuanense Wei Li bis & L. Guo, **sp. nov.** Figs 10–12

FN 570632

Differs from *Annulohypoxylon multiforme* by its tissues with KOH-extractable pigments brown or reddish brown and its ostioles occasionally encircled with an inconspicuous *truncatum*-type disc.

Figs 10–18. ***Annulohypoxylon sichuanense*** (HMAS 281263, holotype). 10. Stromata on wood; 11, 12. Ascospores. ***Annulohypoxylon maeteangense*** (HMAS 247821). 13. Stromata on wood; 14, 15. Ascospores. ***Annulohypoxylon substygium*** (HMAS 247819). 16. Stromata on wood; 17, 18. Ascospores.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Type: China, Sichuan, Xiangtang, Hazhai, on decayed wood, 11.VIII.2013, W. Li & G. Huang 2278 (**Holotype**, HMAS 281263).

Etymology: The epithet refers to type locality, Sichuan Province.

Stromata peltate, with constricted base, usually confluent, with inconspicuous perithecial mounds, 1.8–2.3 × 1–1.7 cm, 1.5–5 mm thick; surface dark brown to blackish brown; blackish brown granules immediately beneath surface, with KOH-extractable brown or reddish brown pigment; the tissue below the perithecial layer conspicuous, blackish brown, 0.7–3 mm thick. Perithecia subspherical to obovate, 0.6–0.8 mm high, 0.3–0.7 mm broad. Ostioles conical-papillate, often without encircling disc or occasionally encircled with an inconspicuous *truncatum*-type disc, 0.1–0.2 mm diam. Asci 136–210 μm long overall, the spore-bearing parts 64–121 × 5–6 μm above 65–140 μm long stipes. Ascus apical ring bluing in Melzer's iodine reagent, discoid, 1–1.5 μm high, 2–2.5 μm diam. Ascospores brown, unicellular, ellipsoid-inequilateral, with narrowly rounded ends, 8–12 × 3.5–5 μm, with straight germ slit, shorter than spore-length; perispore dehiscent in 10% KOH, smooth, epispore smooth.

Comments: *Annulohypoxylon sichuanense* is similar to *A. multiforme* (Fr.) Y.M. Ju & al., which differs in its tissues with KOH-extractable greenish olivaceous pigments and ostioles without an encircling disc.

Annulohypoxylon maeteangense J. Fourn. & M. Stadler, Fungal Diversity 40: 32, 2010. Figs 13–15

Stromata irregularly pulvinate, with conspicuous perithecial mounds, 0.2–4 × 0.1–2.3 cm, 0.6–0.75 mm thick, often rosellinoid at the margins, surface dark brown to black with an olivaceous tones; olivaceous to brown granules immediately beneath surface, with KOH-extractable dull green pigment; the tissue below the perithecial layer inconspicuous, black. Perithecia spherical, 0.3–0.4 mm diam. Ostioles conical-papillate, black and shiny, encircled by a slightly concave *truncatum*-type disc, 0.15–0.25 mm diam. Asci 100–118 μm long overall, the spore-bearing parts 60–83 × 4–5 μm above 32–40 μm long stipes. Ascus apical ring bluing in Melzer's iodine reagent, discoid, 0.8–1 μm high, 1.5–2 μm broad. Ascospores brown, unicellular, ellipsoid-inequilateral, with narrowly to broadly rounded ends, 6.5–8.5 × 3–4 μm, with straight germ slit almost spore-length; perispore dehiscent in 10% KOH, smooth, epispore smooth.

Specimens examined: **CHINA**, **Hainan**, **Qionghai**, Niululing, alt. 116 m, on wood, 4.XII.2009, Y.F. Zhu & L. Guo 11 (HMAS 247821); **Wanning**, Shimeiwan, alt. 3 m, on wood, 6.XII.2009, Y.F. Zhu & L. Guo 53 (HMAS 255362).

Comments: Our specimens are morphologically similar to the holotype, but our asci have longer spore-bearing parts; in the holotype from Thailand they measure only 45–62 µm (Fournier & al. 2010).

Annulohypoxylon substygium Sir & Kuhnert, Fungal Diversity. 85:20, 2017.

Figs 16–18

Stromata pulvinate to effused-pulvinate, with inconspicuous perithecial mounds up to ½ exposed, 1–9 × 0.5–3 cm, 0.6–1.1 mm thick; surface black with reddish brown tones to black; black granules immediately beneath surface, with KOH-extractable light brownish black pigment; the tissue below the perithecial layer inconspicuous, black. Perithecia spherical to obovate, 0.4–0.7 mm high, 0.3–0.5 mm broad. Ostioles papillate, encircled by a *bovei*-type disc, 0.25–0.3 mm diam. Asci 96–110 µm total length, the spore-bearing parts 66–68 µm long, 4–4.5 µm broad, the stipes 30–46 µm long. Ascus apical ring weak bluing in Melzer's iodine reagent, discoid, 0.2–0.5 µm high, 1–1.5 µm broad. Ascospores light brown to brown, unicellular, ellipsoid nearly equilateral, with broadly rounded ends, 6.5–8 × 3–3.5 µm, with straight germ slit running almost the entire spore length; perispore dehiscent in 10% KOH, smooth, epispore smooth.

Specimens examined: **CHINA**, **Jiangsu**, **Jurong**, Baohuashan, on decayed wood, 15.IX.1935, H.N. Shen 101 (HMAS 9684); **Hainan**, Ledong, Jianfengling, alt. 850 m, 29.VII.2007, S.H. He 1173 (HMAS 255340); Changjiang, Bawangling, alt. 600 m, 10.V.2009, W. Li & X.Y. Liu 2234 (HMAS 247819); Bawangling, alt. 500 m, 17.II.2017, L. Guo 12136 (HMAS 255358).

Comments: In our specimens the tissue below the perithecial layer was inconspicuous, while it is conspicuous (0.5–0.6 mm thick) in the holotype (Kuhnert & al. 2017).

Discussion

Including the six species reported in this paper, we now recognize 26 *Annulohypoxylon* species in China (Teng 1963; Tai 1979; Bi & al. 1990; Ju & Rogers 1996, 1999; Ju & al. 2004; Ma 2011; Kuhnert & al. 2017).

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Pleurotheciopsis triseptata sp. nov. from China

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Abstract—A new anamorphic species, *Pleurotheciopsis triseptata*, is described and illustrated from specimens collected on dead stems in China. This fungus is characterized by polyblastic and sympodial conidiogenous cells producing catenate, fusiform, 3-euseptate, versicolored conidia.

Key words—microfungi, hyphomycete, taxonomy

Introduction

Pleurotheciopsis B. Sutton was erected by Sutton (1973) for *P. pusilla* (the type species) and *P. bramleyi*. The genus is characterized by distinct and brown conidiophores with polyblastic, integrated, sympodial, and denticulate conidiogenous cells that produce euseptate and hyaline to brown conidia that form acropetal unbranched chains (Sutton 1973, Ellis 1976, Castañeda & al. 2001). Assigning species in *Pleurotheciopsis* is primarily based on conidial morphological characters, including shape, septation, size, and pigmentation. Five additional species have been described (Castañeda 1985, Cazau & al. 1993, Castañeda & Iturriaga 1999, Castañeda & al. 2001, Rambelli & al. 2008), but *P. setiformis* (with synchronous and ampulliform conidiogenous cells and setae around the conidiophores) was subsequently transferred to *Ampullicephala* by R.F. Castañeda & al. (2009). Castañeda & al. (2001) provided a key to five of the accepted *Pleurotheciopsis* species.

During a survey on wood-inhabiting microfungi in China, a new species that belongs to the genus *Pleurotheciopsis* was found. Specimens are deposited in the Herbarium of Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong, China (HSAUP) and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Taxonomy

Pleurotheciopsis triseptata L.G. Ma & X.G. Zhang, **sp. nov.** FIG. 1

MycoBank MB 831794

Differs from *Pleurotheciopsis sylvestris* by its 3-euseptate and smaller conidia, and from *P. bramleyi* and *P. websteri* by its 3-euseptate and versicolored conidia that are bigger than *P. bramleyi* and shorter than *P. websteri*.

Type: China, Sichuan Province, Longchi National Forest Park, on dead stems of an unidentified broadleaf tree, 22 Apr. 2012, L.G. Ma (**Holotype**, HSAUP H2239; **isotype**, HMAS 146166).

Etymology: *triseptata*, referring to the number of conidial septa.

Colonies on the natural substratum effuse, brown to dark brown, hairy. Mycelium partly superficial, partly immersed, composed of branched, septate, pale brown, smooth hyphae, 2.0–3.5 µm diam. Conidiophores macronematous, mononematous, single, unbranched, erect, straight to flexuous, cylindrical, smooth, thick-walled, brown to dark brown, pale brown towards the apex, 4–9-septate, 105–240 µm long, 6.5–13.5 µm diam at the base, 4–6.5 µm wide at the tapered apex. Conidiogenous cells integrated, terminal, polyblastic, sympodial, brown, cylindrical, smooth, thick-walled, with 1–4 short, unthickened denticles, 29.5–60 × 4.5–6.5 µm. Conidial secession schizolytic. Conidia in distinct, unbranched, acropetal chains, fusiform, sometimes curved, thick-walled, middle cells brown and end cells pale brown to subhyaline, tapered towards the ends, 3-euseptate, intercalary conidia 24–33.5 × 5.5–7.5 µm, truncate at the ends, apical conidia 22.5–33 × 6–7.5 µm, obtuse at the apex and truncate at the base.

Comments—*Pleurotheciopsis triseptata* is most similar to *P. sylvestris* R.F. Castañeda & Iturr. in conidial shape and pigmentation, but *P. sylvestris* has conidia that are 4–7-septate and larger (29–49 × 7–8.5 µm; Castañeda & Iturriaga 1999). *Pleurotheciopsis bramleyi* B. Sutton and *P. websteri* Cazau & al. also resemble our new species, but *P. bramleyi* has conidia that are hyaline, 2–3-septate, and smaller (16.5–25 × 4.5–6.5 µm; Sutton 1973),

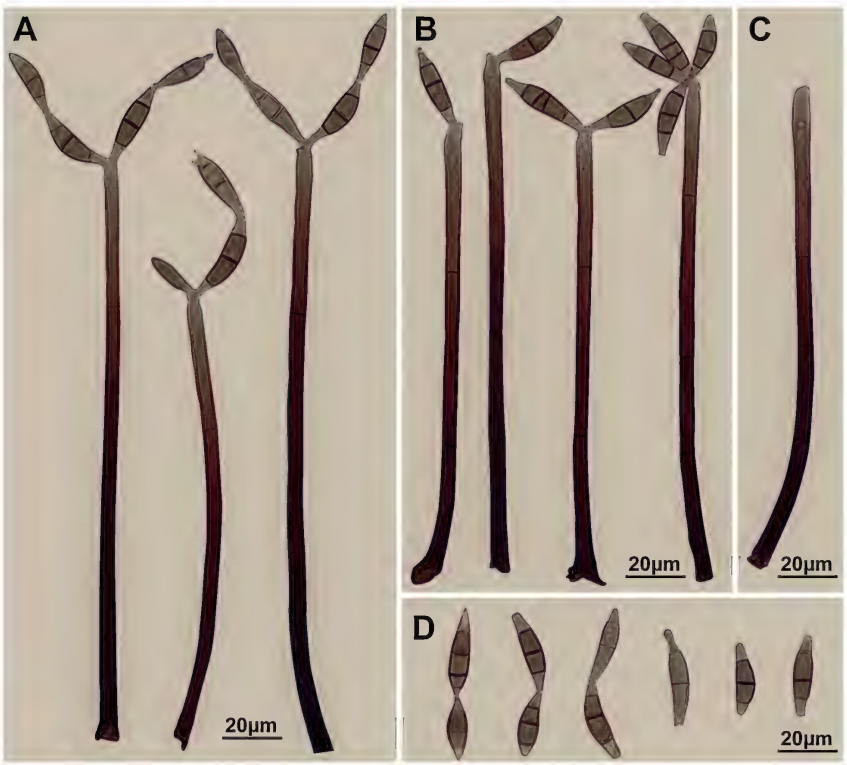

Fig. 1. *Pleurotheciopsis triseptata* (holotype, HSAUP H2239).
A, B. Conidiophores, conidiogenous cells, and conidia;
C. Conidiophore with conidiogenous cell; D. Conidia.

while conidia in *P. websteri* are 5-septate, hyaline, longer, and narrower (32–38 × 5–6 μm; Cazau & al. 1993).

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Repetophragma verrucosum sp. nov. from China

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Abstract—A new anamorphic species, *Repetophragma verrucosum*, is described and illustrated from specimens collected on decaying branches in China. This fungus is distinguished by monoblastic and annellidic conidiogenous cells that produce fusiform to subobclavate, 3-euseptate, verrucose, and yellowish brown conidia.

Key words—hyphomycete, taxonomy, microfungi

Introduction

The vegetation in China is composed of a great variety of evergreen and deciduous broadleaf forests where many different kinds of wood-inhabiting fungi have been recently discovered (e.g., Ma & al. 2016a,b, 2018). During our ongoing study of anamorphic fungi from this region, we collected a species with morphological characters of *Repetophragma* Subram. (Subramanian 1992) from decaying branches. Our specimen, which differed morphologically from previously described *Repetophragma* species, is proposed here as a new species.

The specimens are deposited in the Herbarium of Department of Plant Pathology, Shandong Agricultural University, Taian, Shandong, China (HSAUP) and the Mycological Herbarium, Institute of Microbiology, Chinese Academy of Sciences, Beijing, China (HMAS).

Taxonomy

Repetophragma verrucosum L.G. Ma & X.G. Zhang, **sp. nov.** FIG. 1

MB 831795

Differs from *Repetophragma dennisii* by its narrower, longer, verrucose conidia; and from *R. laxisporum* by its 3-euseptate, wider, verrucose conidia.

TYPE: China, Guangdong Province, Liuxihe National Forest Park, on dead branches of an unidentified broadleaf tree, 12 Oct. 2010, L.G. Ma (**Holotype**, HSAUP H7082; **isotype**, HMAS 146165).

ETYMOLOGY: *verrucosum*, referring to the verrucose conidial wall.

COLONIES on the natural substratum effuse, brown to dark brown, hairy. Mycelium partly superficial, partly immersed, composed of septate, pale brown, smooth hyphae, 2.5–3.5 µm diam. CONIDIOPHORES macronematous, mononematous, single, unbranched, erect, straight to slightly flexuous, cylindrical, smooth, thick-walled, dark brown to black, brown towards the apex, multiseptate, 190–335 × 6.0–8.5 µm. CONIDIOGENOUS CELLS holoblastic, monoblastic, integrated, terminal, indeterminate, brown, cylindrical, smooth, thick-walled, with numerous annellidic percurrent extensions towards the apex. Conidial secession schizolytic. CONIDIA acrogenous, solitary, fusiform to subobclavate, thick-walled, yellowish brown, slightly paler at the end cells, straight or slightly curved, verrucose, 3-euseptate, 23–37.5 × 7.5–10.5 µm, 2.5–4.5 µm diam. at the truncate base, rounded or slightly acute at the apex.

COMMENTS—Subramanian (1992) segregated *Repetophragma* with *R. biseptatum* (M.B. Ellis) Subram. as its type species from *Sporidesmium* Link. The genus is diagnosed by macronematous and single conidiophores possessing integrated and terminal conidiogenous cells with annellidic percurrent extensions and solitary and euseptate conidia (Wu & Zhuang 2005, Castañeda & al. 2011). Castañeda & al. (2011) reviewed the genus, proposed a new species and twelve new combinations, and provided a comparative table and a key to 32 accepted *Repetophragma* species. Among three additional species since added are *R. hainanense* Jian Ma & X.G. Zhang and *R. elegans* J.W. Xia & X.G. Zhang, described from China (Ma & al. 2014, Wang & al. 2017).

Repetophragma verrucosum resembles *R. dennisii* (M.B. Ellis) Subram. and *R. laxisporum* (R.F. Castañeda) R.F. Castañeda in conidial shape. However, the conidia of *R. dennisii* are shorter and wider (23–32 × 11–13 µm), smooth, and brown with paler apical cells (Subramanian 1992); and *R. laxisporum*

Fig. 1. *Repetophragma verrucosum* (holotype, HSAUP H7082).
A. Conidiophores, conidiogenous cells, and conidia;
B. Conidiophores with conidiogenous cells; C. Conidia.

differs from our species by producing 6–7-septate, slightly narrower (7–9 μm), smooth, brown conidia with subhyaline end cells (Castañeda & al. 2011).

Acknowledgments

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Pseudopyricularia cyperi, a new record for Iran

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Abstract—During a survey of sedge plants in northern Iran, three specimens of *Pseudopyricularia cyperi* were isolated from *Cyperus* sp. Their taxonomical identity was established by their spore and conidiophore morphology and ITS rDNA sequence analysis. The specimens are described and illustrated. *Pseudopyricularia cyperi* is a new record for Iran.

Key words—*Magnaporthales*, phylogeny, *Pyriculariaceae*, taxonomy

Introduction

Pyriculariaceae was established as a new family of the *Magnaporthales* by Klaubauf & al. (2014). The family contains ten genera: *Bambusicularia, Barretomyces, Deightoniella, Macgarvieomyces, Neocordana, Neopyricularia, Proxipyricularia, Pseudopyricularia, Pyricularia,* and *Xenopyricularia* (Klaubauf & al. 2014, Hernández-Restrepo & al. 2015). Some species originally described in *Pyricularia* have been transferred to these new genera; e.g., *Macgarvieomyces borealis, Proxipyricularia zingiberis, Neopyricularia commelinicola, Pseudopyricularia higginsii,* and *Xenopyricularia zizaniicola.*

Pyricularia higginsii Luttr. was transferred to *Dactylaria* by Ellis (1976), but Bussaban & al. (2003) maintained the species in *Pyricularia* based on rDNA ITS sequence analysis. On the basis of analyses of five gene regions, Klaubauf

& al. (2014) placed some isolates previously identified as *Pyricularia higginsii* in a new genus *Pseudopyricularia* and separated them into *Pseudopyricularia higginsii* and two new species, *P. cyperi* and *P. kyllingae*.

Additional species since described or combined in *Pseudopyricularia* include *P. bothriochloae, P. hagahagae, P. hyrcaniana, P. iraniana,* and *P. persiana* (Crous & al. 2015, 2018; Pordel & al. 2017; Marin-Felix & al. 2017; Jayawardena & al. 2019). *Pseudopyricularia* species are primarily distinguished from *Pyricularia* sensu stricto by having short, determinate, brown conidiophores with an apical rachis with flat-tipped denticles; they are similar to each other in conidial size and can be resolved only by phylogenetic analysis (Klaubauf & al. 2014; Pordel & al. 2015, 2017). Pordel & al. (2017) reassessed the morphological criteria, and re-described *Pseudopyricularia* conidia as obclavate, fusiform, cylindrical, and 1–2-septate.

Here we describe and illustrate *Pseudopyricularia cyperi* from Iranian specimens and compare them with other species in *Pseudopyricularia*.

Materials & methods

Sampling and fungal isolates

Plant material was obtained from Mazandaran Province in Iran during the summer and fall of 2012 and 2015. Leaves of *Cyperus* sp. with leaf spot symptoms were collected and stored in a refrigerator at 4 °C until used. To induce sporulation of *Pseudopyricularia*, leaf pieces were surface sterilized for 2 min in 1% sodium hypochlorite, dried on filter paper, and then incubated on wet filter paper at 25 °C. Conidia produced on these surface-sterilized leaf pieces were transferred to water agar (WA). Single hyphal tips emerging from germinating conidia were then transferred to potato dextrose agar (PDA) medium (Pordel & al. 2015).

Living cultures have been deposited in the herbarium in the Department of Plant Protection, Faculty of Agricultural Sciences & Engineering, University of Tehran, Karaj, Iran (UTFC).

Morphological characterization

Cultures were grown on oatmeal agar (OA) and PDA to determine overall colony morphology and characteristics. Micromorphological characters were determined from colonies grown on synthetic nutrient-poor agar (SNA; Nirenberg 1976), and WA supplemented with pieces of rice leaves. Plates were incubated at 23–25 °C under a regime of 12 h dark/12 h near-ultraviolet light and examined for sporulation after 1–3 wks. Measurements and microphotographs were taken from slide mounts in lactophenol and lactophenol cotton blue. Measurements were taken from 70–100 conidiophores and 200 conidia. Photographs were taken using a Sony digital camera mounted on an Olympus BH2 microscope.

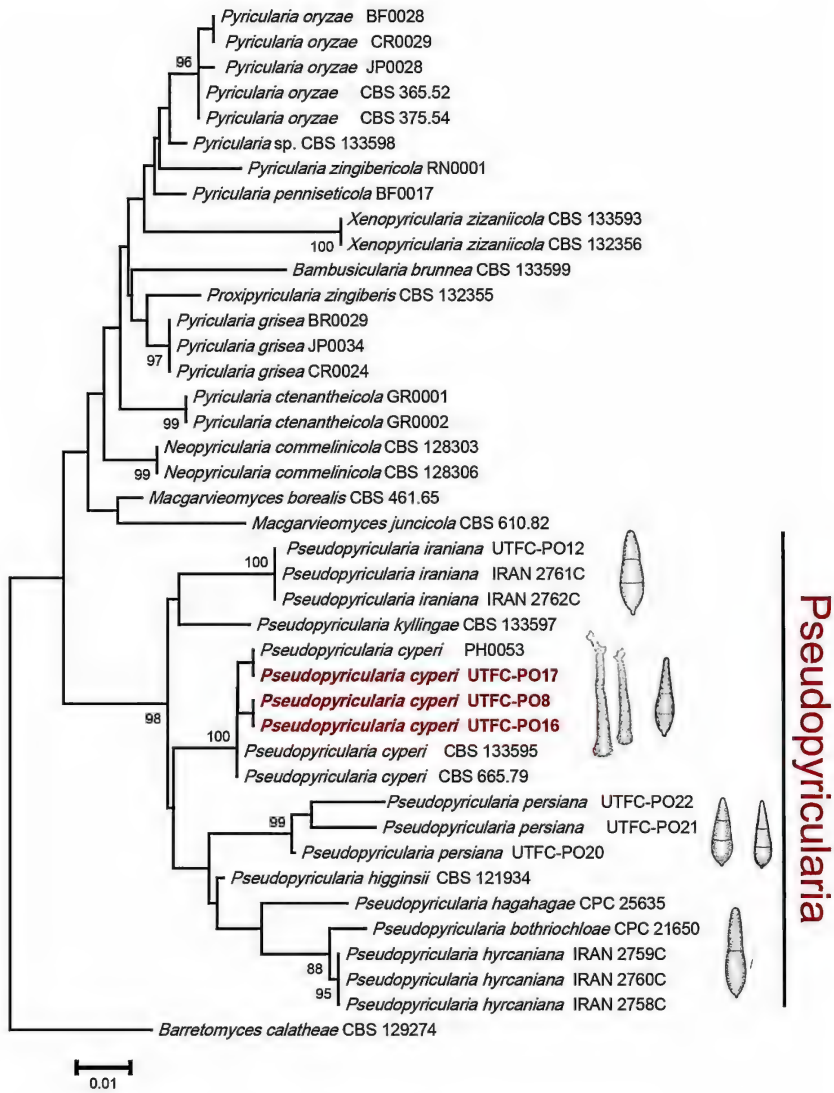

FIG. 1. Maximum likelihood tree inferred from ITS sequence of *Pyriculariaceae* species. Branch values of ML >80% are noted above internodes. Strains of *Pseudopyricularia cyperi* from Iran are in bold.

Phylogenetic analysis

The three isolates of *Pseudopyricularia cyperi* collected in Iran were used for phylogenetic analysis. Total genomic DNA was extracted using the protocol of Zhong & Steffenson (2001) and the ITS region was amplified according to Klaubauf & al. (2014). Additional ITS sequences were downloaded from GenBank. A total of 41 nucleotide sequences (including GenBank sequences originating from Klaubauf & al. 2014) were analyzed. *Barretomyces calatheae* was used as outgroup (Klaubauf & al. 2014).

The sequences were edited by CLC Genomic Workbench 10.1 and aligned using MUSCLE (Edgar 2004). Phylogenetic analyses were performed with MEGA v. 6 (Tamura & al. 2013). A phylogenetic tree was constructed using the maximum likelihood method based on the Kimura two-parameter model (Kimura 1980). The percentage of replicate trees in which the associated taxa clustered together in the bootstrap test (1000 replicates) are shown next to the branches. The tree is drawn to scale, with branch lengths in the same units as those of the evolutionary distances used to infer the phylogenetic tree. The evolutionary distances were computed using the maximum composite likelihood method and are in the units of the number of base substitutions per site. All positions with less than 95% site coverage were eliminated, permitting fewer than 5% alignment gaps, missing data, and ambiguous bases at any position. The final ITS dataset comprised 296 positions.

Results

Phylogenetic analysis

Our phylogenetic analyses grouped *Pseudopyricularia* species together in one clade within *Pyriculariaceae* with a high (bootstrap >98%) statistical support (Fig. 1). These species have variously shaped 1–2-septate conidia. All are pathogenic to plants but have different hosts and have likely evolved separately. The phylogeny (Fig. 1) demonstrates a 100% MLBP support for a close relationship between known *P. cyperi* isolates and the strains isolated from *Cyperus* sp. in Iran, supporting classification of the Iranian samples as *Pseudopyricularia cyperi*. In particular, isolate UTFC-P016 has the same ITS sequences as *P. cyperi* CBS 133595 (ex-holotype; from Japan) and isolate UTFC-P017 has the same ITS sequences as *P. cyperi* PH0053 (ex-paratype; from Philippines).

Taxonomy

Pseudopyricularia cyperi Klaubauf, M.-H. Lebrun & Crous, Stud. Mycol. 79: 110. 2014. Figs 2, 3

Colonies grown on PDA after 1 wk at 23–25 °C white, reaching 40 mm diam. Conidiophores solitary, erect, straight or curved to geniculate, branched,

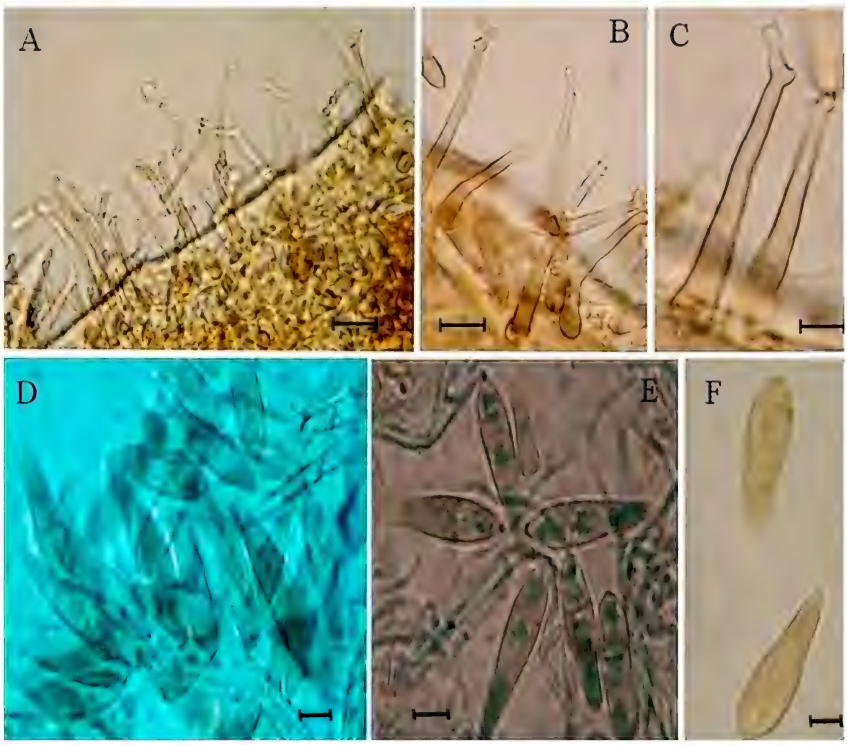

Fig. 2. *Pseudopyricularia cyperi* (UTFC-PO8). A–C. Solitary, erect, branched, and unbranched conidiophores; D–F. Conidia. Scale bars = 10 µm.

medium brown, smooth, 40–100 × 3–4 µm. Conidiogenous cells integrated, terminal and intercalary, pale brown, smooth, forming a rachis with several protruding, flat-tipped denticles. Conidia solitary, obclavate, medium brown, smooth to finely roughened, 2-septate, 22–29 × 5–6 µm; hilum truncate, slightly protruding, unthickened, not darkened.

Specimens examined—On infected leaves of *Cyperus* sp. **IRAN**, **Mazandaran province**, Amol, 25 July 2012, Adel Pordel cy2k (UTFC-PO8; GenBank KP144446), Adel Pordel cy4-1 (UTFC-PO16; GenBank MF768983), Adel Pordel cy2k1 (UTFC-O17 GenBank MF768984).

Comments—The morphology of the Iranian specimens cited above agree with the protologue description of *Pseudopyricularia cyperi* (Klaubauf & al. 2014). This species is morphologically similar to *P. higginsii* (Luttr.)

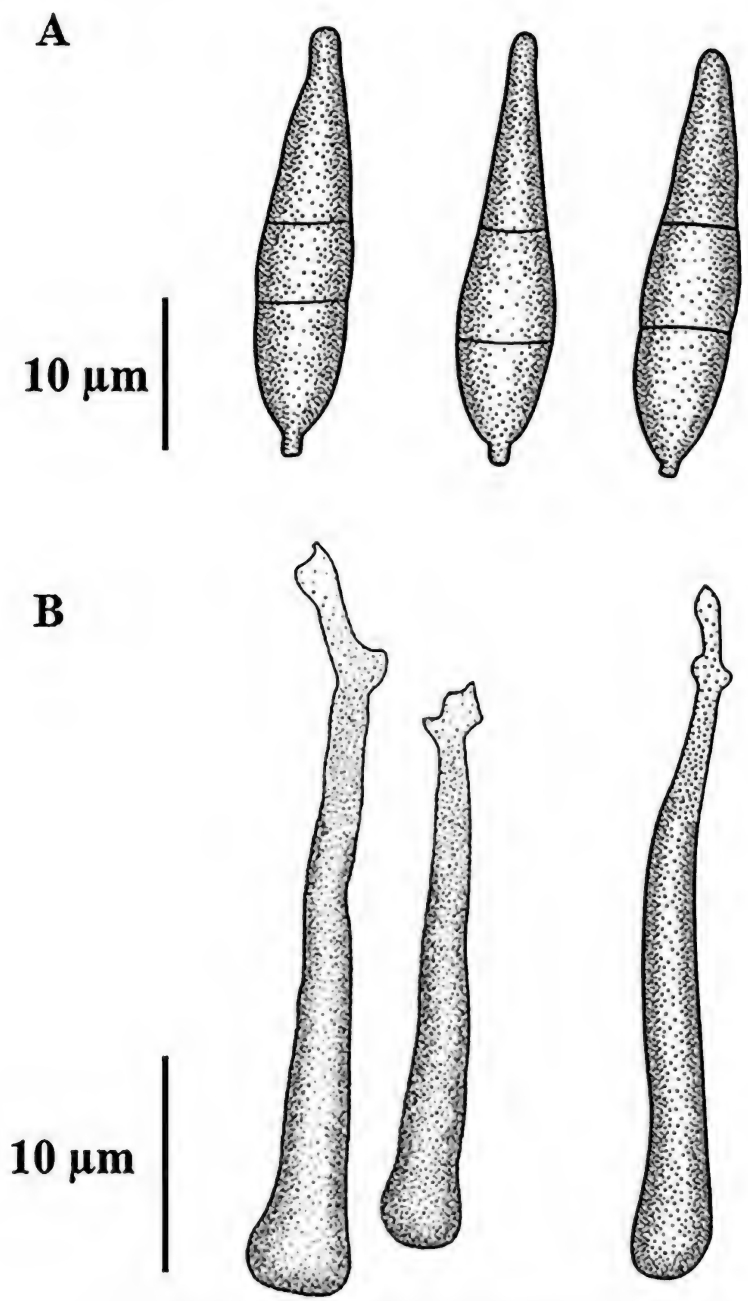

FIG. 3. *Pseudopyricularia cyperi* (UTFC-PO8). A. Conidia; B. Conidiophores

Klaubauf & al., which differs by its longer and slightly wider conidia (17.5–36.5 × 5.3–6.5 µm, Luttrell 1955; 20–36 × 5–6 µm, Ellis 1976). This represents the first report of *Pseudopyricularia cyperi* in Iran.

Discussion

The order *Magnaporthales* has been reclassified into three families, *Magnaporthaceae*, *Pyriculariaceae*, and *Ophioceraceae* (Klaubauf & al. 2014, Luo & al. 2015, Pordel & al. 2017). The *Pyriculariaceae* is characterized by *Pyricularia*-like asexual states and pathogenicity to *Poaceae* or other monocotylenous plants. Phylogenetic analysis based on five gene regions allowed definition of several new genera and species in *Pyriculariaceae* (Klaubauf & al. 2014).

Previously, several species of *Pseudopyricularia* were unrecognized and placed in the *P. higginsii* complex. Based on phylogenetic analysis, new *Pseudopyricularia* species were identified in this clade (Klaubauf & al. 2014, Pordel & al. 2017). *Pseudopyricularia* and *Macgarvieomyces* are morphologically and phylogenetically similar (Klaubauf & al. 2014, Pordel & al. 2017). *Macgarvieomyces* is distinguished from *Pseudopyricularia* and *Pyricularia* sensu stricto by its production of chlamydospores, mostly unbranched conidiophores, and narrowly obclavate, granular, guttulate and 1-septate conidia (Pordel & al. 2017). *Pseudopyricularia bothriochloae* (Crous & Cheew.) Y. Marín & Crous is closely related to *P. hyrcaniana* Pordel & Jav.-Nikkh (both with 1-septate conidia), while *P. hagahagae* Crous & M.J. Wingf. (with 2-septate conidia) is clearly separated from them phylogenetically (Fig. 1). The phylogeny also supports five species (*P. higginsii*, *P. iraniana* Pordel & Jav.-Nikkh, *P. cyperi*, *P. persiana* G. Ghorbani & al., and *P. kyllingae* Klaubauf & al.) as separate from species having 1-septate conidia. *Pseudopyricularia cyperi* strains from Iran, which lie in *P. cyperi* clade, are morphologically similar to all previous records of this species from *Cyperus* sp. in other countries (Klaubauf & al. 2014; Borromeo & al. 1993, as "*P. higginsii*").

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Morganjonesia gen. nov. for two atypical *Corynespora* and *Teratosperma* species

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Abstract—*Morganjonesia* is proposed as a new genus for two species, *Corynespora calophylli* and *Teratosperma litchii*, which have monotretic conidial ontogeny on the terminal conidiogenous cells and solitary, euseptate, verruculose, brown conidia with a single, subulate or acute, hyaline conidial appendage at the apex (sometimes with another downwardly-direct conidial appendage). Illustrations of both species are provided.

Key words—asexual *Ascomycota*, hyphomycetes, systematics

Introduction

Corynespora Güssow, typified by *C. mazei* Güssow [= *C. cassiicola* (Berk. & M.A. Curtis) C.T. Wei], is distinguished by macronematous, mononematous, and generally unbranched, erect conidiophores and monotretic, terminal, integrated, determinate or with several doliiform, enteroblastic percurrent extension conidiogenous cells. The conidiogenous loci are apical, slightly

depressed, somewhat melanized, and thickened around the pore to produce solitary or blastocatenate, multidistoseptate, obclavate, cylindrical, obovate, oval, smooth-walled or verruculose, pale pigmented conidia usually with a slightly melanized basal scar (Morgan-Jones 1988, Seifert & al. 2011). *Corynespora calophylli* clearly deviates from the generic concept of *Corynespora*, because it is characterized by monotretic conidial ontogeny and solitary, 2-euseptate, obclavate to obpyriform, brown conidia with an apical, acute, hyaline conidial appendage, slightly papillate at the truncate base (Holubová-Jechová & Castañeda-Ruiz 1986).

Teratosperma Syd. & P. Syd., typified by *T. singulare* Syd & P. Syd., is characterized by macronematous, mononematous, generally unbranched, erect conidiophores and monoblastic, terminal, integrated, indeterminate conidiogenous cells with several annellidic enteroblastic percurrent extensions. The conidia are staurospore, tetraradiate, rostrate, brown to olivaceous brown, septate at the main axis, with 1–3-basal arms, and pale pigmented (Ellis 1971, Seifert & al. 2011). *Teratosperma litchii* clearly deviates from the generic concept of *Teratosperma*, because it is distinguished by a monotretic conidial ontogeny and solitary, 3(–4)-euseptate, obclavate, brown conidia with 1-2 apical, subulate, hyaline appendage that are slightly papillate at the truncate base (Matsushima 1980).

Here we propose a new genus, *Morganjonesia*, to accommodate these two atypical species.

Taxonomy

Morganjonesia R.F. Castañeda, K. Zhang & D.W. Li, **gen. nov.**

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Differs from *Corynespora* species by its euseptate conidia with an acute or subulate, hyaline apical or downwardly direct conidial appendage; and differs from *Teratosperma* species by its monotretic conidial ontogeny.

Type species: *Corynespora calophylli* Hol.-Jech. & R.F. Castañeda [≡ *Morganjonesia calophylli* (Hol.-Jech. & R.F. Castañeda) R.F. Castañeda & al.]

Etymology: Latin, *Morganjonesia*, in honor of Dr. Gareth Morgan-Jones in recognition of his contributions to the study of hyphomycetes.

Conidiophores macronematous, mononematous, unbranched, erect, straight, cylindrical, septate, smooth, brown to dark brown. Conidiogenous cells monotretic, integrated, terminal, cylindrical, determinate or sometimes with one or several oblong enteroblastic percurrent extensions. Conidial secession schizolytic. Conidia solitary, acrogenous, obclavate to obpyriform, euseptate,

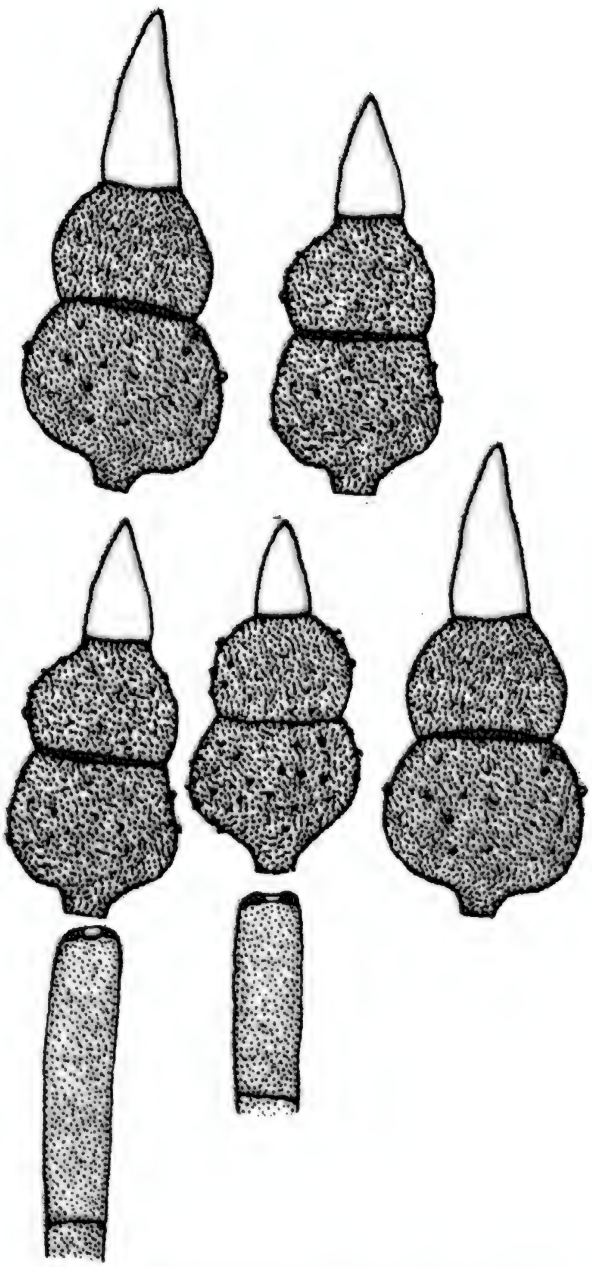

Fig. 1. *Morganjonesia calophylli* (holotype, INIFAT C84/150).
A. Conidia with single apical conidial appendages; B. Conidiogenous cells with tretic loci.

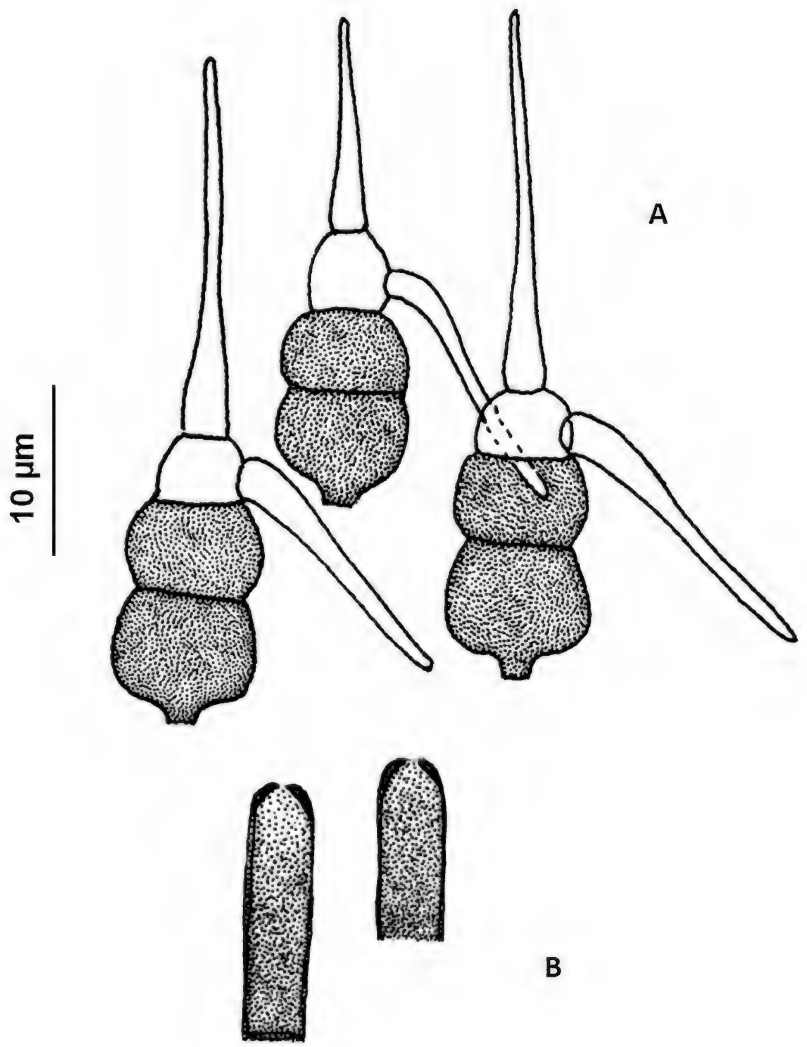

Fig. 2. *Morganjonesia litchii* (holotype, MFC 9048).
A. Conidia with two conidial appendages; B. Conidiogenous cells with tretic loci.

constricted at the septa, slightly papillate at the truncate base, brown or dark brown, smooth-walled or verruculose, with 1–2 acute or subulate, hyaline, smooth conidial appendages at the apex.

Morganjonesia calophylli (Hol.-Jech. & R.F. Castañeda.) R.F. Castañeda, K. Zhang & D.W. Li, **comb. nov.** Fig. 1

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≡ *Corynespora calophylli* Hol.-Jech. & R.F. Castañeda, Česká Mykol. 40(2): 83 (1986).

Morganjonesia litchii (Matsush.) K. Zhang & R.F. Castañeda, **comb. nov.** Fig. 2

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≡ *Teratosperma litchii* Matsush., Matsush. Mycol. Mem. 1: 73 (1980).

Note: *Solicorynespora* R.F. Castañeda & W.B. Kendr., typified by *S. zapatensis* R.F. Castañeda & W.B. Kendr., is similar to *Morganjonesia* in the monotretic conidial ontogeny and the solitary, euseptate conidia (Hernández-Restrepo & al. 2014, Ma & al. 2016), but its protologue (Castañeda-Ruiz & Kendrick 1990) did not describe a hyaline, acute or subulate conidial appendage.

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Botryosphaeria qinlingensis sp. nov. causing oak frogeye leaf spot in China

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Abstract — During our investigation on plant diseases in Qinling Mountain in China, an oak disease with frogeye leaf spot symptoms was discovered. The associated pathogen was characterised by morphological and molecular approaches and is described here as a new species, *Botryosphaeria qinlingensis*.

Key words — *Botryosphaeriaceae, Botryosphaeriales,* taxonomy

Introduction

Botryosphaeria was firstly proposed by Cesati & De Notaris (1863) without designating a type species. Subsequently, *B. berengeriana* (Höhnel 1909) and *B. quercuum* (Theissen & Sydow 1915) were designated as the type, but neither species was included in the original description of the genus. Barr (1972) proposed *B. dothidea* (Moug. ex Fr.) Ces. & De Not. as the type species, because it was one of the original species and an earlier synonym of *B. berengeriana*. *Botryosphaeria dothidea* is now universally accepted as the type of the genus. Slippers & al. (2004) provided a revised description of *B. dothidea* based on the type specimen and fresh collections and designated a neotype and epitype.

Botryosphaeria was restricted to *B. dothidea* and *B. corticis* (Crous & al. 2006), but subsequently, *B. agaves, B. auasmontanum, B. fabicerciana, B. fusispora, B. kuwatsukai, B. minutispermatia, B. pseudoramosa, B. qingyuanensis,*

B. quercus, B. ramosa, B. rosaceae, B. scharifii, B. sinensis, and *B. wangensis* have been accepted in this genus (Abdollahzadeh & al. 2013; Ariyawansa & al. 2016; Chen & al. 2011; Li & al. 2018; Liu & al. 2012; Pavlic & al. 2008; Slippers & al. 2014; Wijayawardene & al. 2016; Xu & al. 2015; Zhou & al. 2016, 2017).

Quercus is an important tree genus that contains many commercial taxa widespread from temperate to subtropical broad-leaved forests in China, such as *Q. acutissima, Q. aliena, Q. aliena* var. *acutiserrata, Q. variabilis,* and *Q. wutaishanica*. A disease with frogeye leaf spot symptoms was discovered on the leaf surface of *Q. aliena* var. *acutiserrata* and *Q. acutissima* (Plate 1). Similar symptoms have been recorded on *Q. dentata, Q. acutissima, Q. aliena, Q. aliena* var. *acutiserrata,* and *Q. variabilis,* and the agents causing those symptoms were identified as *Macrophoma* species (Tian & al. 1991). Here we present an accurate identification based on combined morphology and DNA sequence data, and describe the pathogen as a new species, *Botryosphaeria qinlingensis*.

Materials & methods

Samples and isolates

In this study, diseased oak leaves were collected from *Quercus aliena* var. *acutiserrata* and *Q. acutissima* in Shaanxi Province in China. Single conidial isolates were obtained from conidiomata by removing a mucoid conidial mass from pycnidial ostioles following Jiang & al. (2018). Specimens of the new species were deposited in the Museum of Beijing Forestry University, Beijing, China (BJFC). Axenic cultures were maintained in the China Forestry Culture Collection Center, Beijing, China (CFCC).

Morphological studies

Species identification was based on conidial morphology and fruiting bodies were observed according to Slippers & al. (2013). Fifty spores were selected randomly for measurement using a Leica compound microscope (LM, DM 2500). Morphological or cultural characteristics were observed on PDA after incubation at 25 °C and recorded at 5 and 10 days, including colony color and texture.

DNA extraction, PCR amplification, and sequencing

Genomic DNA was extracted from fungal mycelium growing on MEA using a modified CTAB method (Doyle & Doyle 1990). The internal transcribed spacer of rDNA (ITS) was amplified using primers ITS4 and ITS5 (White & al. 1990). The translation elongation factor-1 alpha (tef1-α) was amplified using primers EF1-688F and EF1-1251R (Alves & al. 2008). The β-tubulin gene (tub) was amplified using primers Bt2a and Bt2b (Glass & Donaldson 1995). These regions were amplified and sequenced following Zhang & al. (2009). The PCR products were estimated visually by

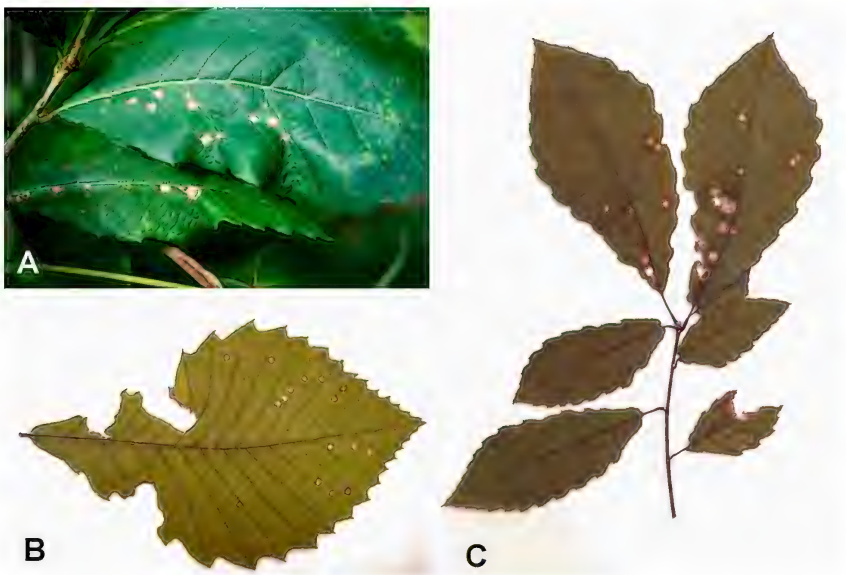

Plate 1. *Botryosphaeria qinlingensis*:
Frogeye disease symptoms on leaves of *Quercus aliena* var. *acutiserrata*.

electrophoresis in 2% agarose gel set to 60 V for 90 min. DNA was sequenced using an ABI PRISM® 3730XL DNA Analyzer with BigDye® Terminater Kit v.3.1 at the Shanghai Invitrogen Biological Technology Company Limited.

DNA sequence analysis

The new sequences generated in this study and the reference sequences of *Botryosphaeria* isolates included in the phylogenetic analyses are summarized in Table 1. *Neofusicoccum luteum* (CBS 110299) was used as outgroup (Li & al. 2018). These sequences were aligned with MAFFT v. 7 (Katoh & Standley 2013) and manually adjusted. Phylogenetic analyses were generated from the combined ITS–tef1α–tub sequences using PAUP v. 4.0b10 (Swofford 2003) for maximum parsimony (MP), PhyML v. 3.0 (Guindon & al. 2010) for maximum likelihood (ML), and MrBayes v.3.1.2 for Bayesian Inference (BI) (Ronquist & Huelsenbeck 2003) following Zhou & al. (2017) and Li & al. (2018).

Results

Molecular phylogeny

The combined ITS, tef1-α, and tub alignment comprised 32 sequences (including one outgroup) and 1344 characters including alignment gaps, of which 1127 were parsimony informative, 95 were variable and parsimony-

Table 1. Isolates used in the molecular analyses.

Species	Isolate number	Host/substrate	Country	GenBank accession numbers		
				ITS	tef1-α	tub
Botryosphaeria agaves	CBS 133992	*Agave* sp.	Thailand	JX646791	JX646856	JX646841
	MFLUCC 10-0051	*Agave* sp.	Thailand	JX646790	JX646855	JX646840
B. auasmontanum	CBS 121769	*Acacia mellifera*	Namibia	EU101303	EU101348	—
B. corticis	CBS 119047	*Vaccinium corymbosum*	USA	DQ299245	EU017539	EU673107
	ATCC 22927	*Vaccinium* sp.	USA	DQ299247	EU673291	EU673108
B. dothidea	CBS 115476	*Prunus* sp.	Switzerland	AY236949	AY236898	AY236927
	CBS 110302	*Vitis vinifera*	Portugal	AY259092	AY573218	EU673106
B. fabicerciana	CBS 127193	*Eucalyptus* sp.	China	HQ332197	HQ332213	KF779068
	CBS 127194	*Eucalyptus* sp.	China	HQ332198	HQ332214	KF779069
B. fusispora	MFLUCC 10-0098	*Entada* sp.	Thailand	JX646789	JX646854	JX646839
B. kuwatsukai	CBS 135219	*Malus domestica*	China	KJ433388	KJ433410	—
	LSP 5	*Pyrus* sp.	China	KJ433395	KJ433417	—
B. minutispermatia	GZCC 16-0013	Dead wood	China	KX447675	KX447678	—
	GZCC 16-0014	Dead wood	China	KX447676	KX447679	—
B. pseudoramosa	CERC1999	*Eucalyptus* hybrid	China	KX277988	KX278093	KX278197

	CGMCC3.18739	*Eucalyptus* hybrid	China	KX277989	KX278094	KX278198
B. qingyuanensis	CGMCC3.18742	*Eucalyptus* hybrid	China	KX278000	KX278105	KX278209
	CGMCC3.18743	*Eucalyptus* hybrid	China	KX278001	KX278106	KX278210
B. qinlingensis	CFCC 52984	*Quercus aliena* var. *acutiserrata*	China	MK434301	MK425020	MK425022
	CFCC 52985	*Quercus acutissima*	China	MK434302	MK425021	MK425023
B. quercus	MFLUCC 14-0459	*Quercus* sp.	Italy	KU848199	—	—
B. ramosa	CBS 122069	*Eucalyptus camaldulensis*	Australia	EU144055	EU144070	KF766132
B. rosaceae	CGMCC3.18007	*Malus* sp.	China	KX197074	KX197094	KX197101
	CGMCC3.18008	*Amygdalus* sp.	China	KX197075	KX197095	KX197102
B. scharifii	CBS 124703	*Mangifera indica*	Iran	JQ772020	JQ772057	—
	CBS 124702	*Mangifera indica*	Iran	JQ772019	JQ772056	—
*B. sinensi***S**	CGMCC3.17723	*Morus* sp.	China	KT343256	KU221233	KX197107
	CGMCC3.17724	*Juglans regia*	China	KT343255	KU221234	KX197108
B. wangensis	CGMCC3.18744	*Cedrus deodara*	China	KX278002	KX278107	KX278211
	CGMCC3.18745	*Cedrus deodara*	China	KX278003	KX278108	KX278212
Dichomera saubinetii	CBS 990.70	Dead branch	Netherlands	KF766153	KF766396	—
Neofusicoccum luteum	CBS 110299	*Vitis vinifera*	Portugal	AY259091	AY573217	DQ458848

uninformative, and 122 were constant. The MP analysis produced 50 equally most parsimonious trees, with the first tree (TL = 261, CI = 0.893, RI = 0.905, RC = 0.808) shown in Plate 2. The ML and BI phylogenetic trees were topologically similar to the MP tree. The new species appeared in a single clade with high bootstrap support (Plate 2).

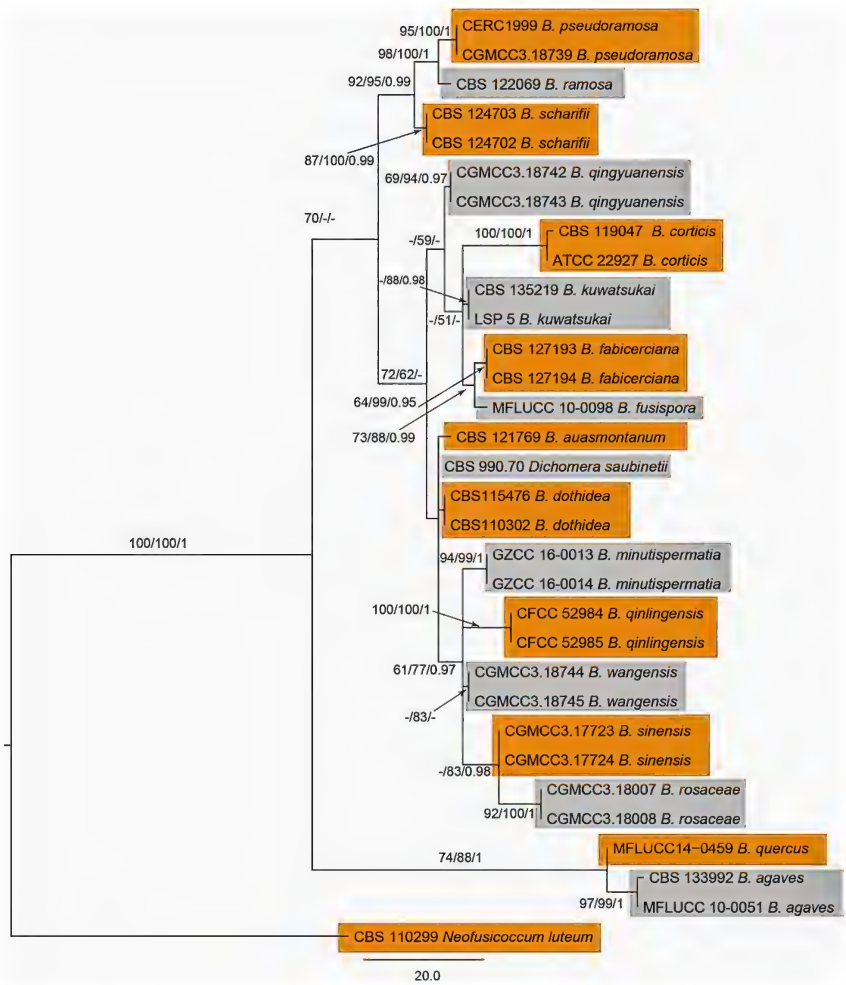

Plate 2. Phylogram of *Botryosphaeria* based on combined ITS, tef1, and tub genes. Bootstrap support values >50% and posterior probability values ≥0.95 are presented as MP/ML/PP, above branches. Scale bar = 20 nucleotide substitutions.

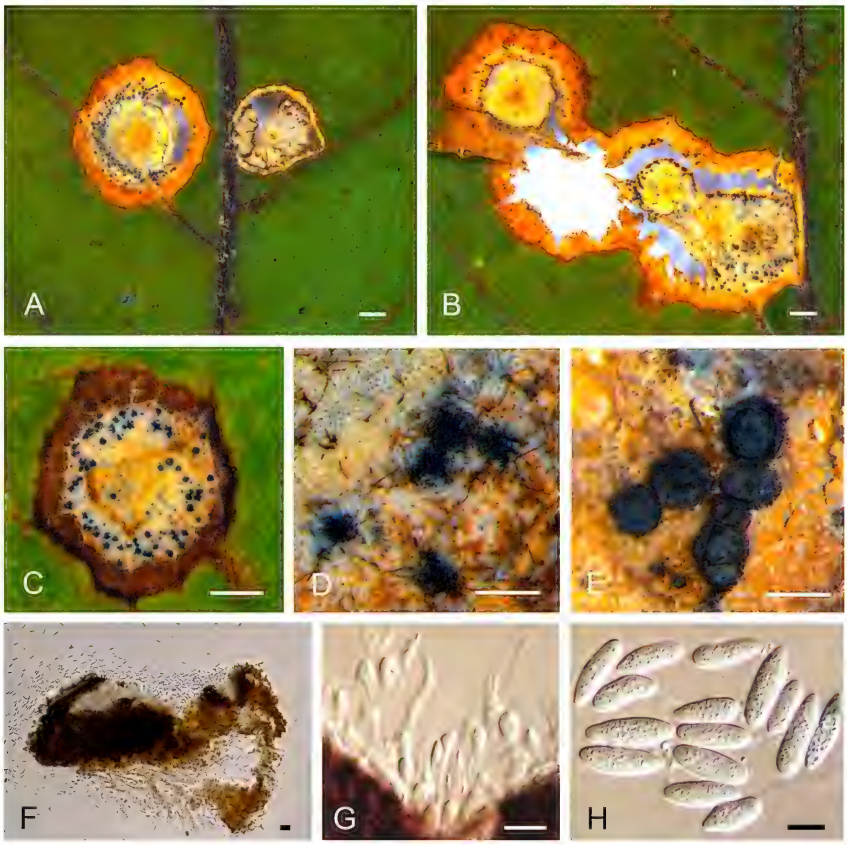

Plate 3. *Botryosphaeria qinlingensis* from *Quercus aliena* var. *acutiserrata* (BJFC-S1576, holotype). A–D. Conidiomata; E. Transverse sections through conidiomata; F. Longitudinal section through a conidioma; G. Conidiogenous cells and developing conidia; H. Conidia. Scale bars: A–C = 1 cm; D, E = 2 mm; F–H = 10 μm.

Taxonomy

Botryosphaeria qinlingensis C.M. Tian & L.Y. Liang, **sp. nov.** Plate 3

MB 828967

Differs from *Botryosphaeria wangensis* and *B. minutispermatia* by its wider conidia.

Type: China, Shaanxi Prov., Ningshan County, Qinling Mountain, Huoditang forest park, 33°26′07″N 108°26′48″E, 1570 m a.s.l, on leaves of *Quercus aliena* var. *acutiserrata*, 3 July 2018, coll. N. Jiang & C.M. Tian (**Holotype,** BJFC-S1576; ex-type culture CFCC 52984; GenBank MK434301, MK425020, MK425022).

Etymology: *qinlingensis*, named after the Qinling Mountain.

Sexual morph: Undetermined. Asexual morph: Conidiomata formed on oak leaf spot, stromatic, brown to black, 120–250 µm diam, forming a botryose aggregate of up to 15 (sometimes solitary) globose with a central ostiole, semi-immersed to superficial. Paraphyses, hyaline, aseptate, up to 35 µm long, 3–5 µm diam. at the base tapering to acutely rounded apices, 1–2 µm diam. at the tip. Conidiophores absent. Conidiogenous cells holoblastic, discrete, hyaline, cylindrical to lageniform, phialidic with periclinal thickening, 4.5–10.5 × 1.5–3 µm. Conidia hyaline, thin-walled, smooth with granular contents, unicellular, aseptate, ellipsoid to fusoid, base subtruncate to bluntly rounded, (14.3–)19.2–24.8(–30.0) × (6.1–)7.1– 8.4(–9.5) µm, L/W = (2.0–)2.4–3.3(–3.7) (n = 100). Colonies initially white with fluffy, aerial mycelium, becoming black on the surface after 5 days; reverse side of the colonies dark-brown.

Additional specimen examined: **CHINA**, **Shaanxi Prov.**, **Ningshan County**, Qinling Mountain, Shibazhang village, 33°26′10″N 108°26′42″E, 1700 m a.s.l, on leaves of *Quercus acutissima*, 7 July 2018, coll. N. Jiang & C.M. Tian (BJFC-S1577; living culture CFCC 52985; GenBank MK434302, MK425021, MK425023).

Host/Distribution: on leaves of *Quercus aliena* var. *acutiserrata* and *Q. acutissima* in China.

Note: The two isolates of *B. qinlingensis* clustered in a well-supported clade (MP/ML/BI = 100/100/1) in Plate 2 and appeared closely related to *B. wangensis* G.Q. Li & S.F. Chen and *B. minutispermatia* Ariyaw. & al. However, *B. qinlingensis* can be morphologically distinguished from *B. wangensis* and *B. minutispermatia*, which differ by their narrower conidia (*B. wangensis*, 5.5–6.5 µm, Li & al. 2018; *B. minutispermatia*, 3–4 µm, Ariyawansa & al. 2016).

Discussion

In this study, disease samples with typical frogeye leaf spot symptom were observed and collected from *Quercus aliena* var. *acutiserrata* and *Quercus acutissima* in Qinling Mountain in China. Based on DNA sequence data of combined ITS, tef1-α, and tub loci, *Botryosphaeria qinlingensis* is proposed here as the pathogen causing oak frogeye leaf spot disease.

Although the sexual state of *Botryosphaeria qinlingensis* was absent, we can still distinguish this pathogen from other *Botryosphaeria* species by conidial dimension (Table 2), supplemented by host information. Another species, *Botryosphaeria quercus*, was recorded on oak leaves collected from Italy and described with only *Dichomera*-like conidia, but we can separate *B. quercus* and *B. qinlingensis* in the phylogenetic tree (Plate 2).

Table 2. Conidial size of accepted *Botryosphaeria* species.

Species	Conidial size (μm)	L/W	Reference
B. agaves	—	—	Liu & al. 2012
B. auasmontanum	(8.1–)8.8–11.3(–13) × (2.5–)2.9–3.9(–5)	3	Slippers & al. 2014
B. corticis	(20.5–)23.5–32.5(–34.5) × (5.0–)5.5–7(–7.5)	4.5	Phillips & al. 2006
B. dothidea	(20–)23–27(–30) × 4–5(–6)	4.9	Slippers & al. 2004
B. fabicerciana	(16.5–)19.5–24.5(–26) × (4.5–)5–6.5(–7.5)	3.8	Chen & al. 2011
B. fusispora	16–22 × 4–5.5	4	Liu & al. 2012
B. kuwatsukai	(18.5–)20–24.5(–26) × 5–7(–8)	3.6	Xu & al. 2015
B. minutispermatia	8–14 × 3–4	3.7	Ariyawansa & al. 2016
B. pseudoramosa	(8–)10–13(–16) × (4–)4.5–5(–6)	2.5	Li & al. 2018
B. qingyuanensis	(15–)19.5–24.5(–28.5) × (5–)6–6.5(–7.5)	3.5	Li & al. 2018
B. qinlingensis	(14.3–)19.2–24.8(–30) × (6.1–)7.1–8.4(–9.5)	2.4–3.3	This study
B. quercus	10–24 × 6–10	—	Wijayawardene & al. 2016
B. ramosa	(11–)12–15(–16) × (4.7–)5–6(–7)	2.3	Pavlic & al. 2008
B. rosaceae	20–31 × 6–8	3.9	Zhou & al. 2017
B. scharifii	(11.5–)13–17(–19) × 4–6.5	2.7	Abdollahzadeh & al. 2013
B. sinensis	(15–)19–29 × 5–7	4.1	Zhou & al. 2016
B. wangensis	(20.5–)22–26(–29) × (4.5–)5.5–6.5(–7.5)	3.9	Li & al. 2018

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Tretoheliocephala cylindrospora sp. nov., an asexual fungus from Thailand

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Abstract—*Tretoheliocephala cylindrospora* is described and illustrated as a new species collected from a decaying twig of an unidentified plant in Phu Laenkha National Park, Chaiyaphum Province, northeastern Thailand. The new fungus, which is compared with *T. compacta,* the type species of the previously monotypic genus, is characterized by unbranched conidiophores that produce solitary, oblong or cylindrical, unicellular conidia.

Key words—microfungi, morphology, plant debris, taxonomy

Introduction

Recent work on fungal biodiversity in Thailand has prompted an increase in the mycobiota of the country with several new species (e.g., Boonyuen & al. 2016; Chuaseeharonnachai & al. 2013, 2014, 2016, 2017; Sri-indrasutdhi & al. 2010, 2015; Yamaguchi & al. 2012). During continuing surveys of microfungi associated with plant materials in Thailand, a *Periconia*-like fungus was collected on an unidentified decaying twig. The conidiogenesis and conidial

morphology placed this fungus in the genus *Tretoheliocephala* Gusmão & al., but it demonstrated clear differences from the single *Tretoheliocephala* species previously described (Gusmão et & al. 2017) and is therefore proposed as new to science.

Materials & methods

Samples of decaying leaves and twigs were collected in October 2013 from Phu Laenkha viewpoint (16°01′N 101°53′E) in Phu Laenkha National Park, Chaiyaphum Province, Thailand. Samples were transported to the laboratory and washed with tap water to remove soil particles and adhering debris. The samples were soaked with sterile distilled water and incubated in moist chambers at room temperature (~20–25°C) for at least 2 weeks. The fungus was isolated under an Olympus SZ61 stereomicroscope using the single spore technique outlined by Goh (1999). Spores were transferred to different media—cornmeal agar (CMA), malt extract agar (MEA), potato carrot agar (PCA), potato dextrose agar (PDA), and water agar (WA) with added 50 µg/mL of two antibiotics (penicillin and streptomycin)—as recommended by Choi & al. (1999) and Kirk & al. (2008), but isolation was unsuccessful.

Fresh material was mounted in water and examined and measured using an Olympus CX31 compound microscope equipped with a drawing tube. Microphotographs were obtained with an Olympus DP70 equipped with Nomarski differential interference optics. Permanent slides are deposited at the BIOTEC Bangkok Herbarium, Thailand (BBH).

Taxonomy

Tretoheliocephala cylindrospora Chuaseehar., Somrith. & Boonyuen, **sp. nov.**

MB 828099 PLATES 1, 2

Differs from T. compacta (type of the monotypic genus) by its solitary, oblong or cylindrical, unicellular conidia on unbranched conidiophores.

TYPE: Thailand, Chaiyaphum Province, Phu Laenkha viewpoint in Phu Laenkha National Park, 16°01′N 101°53′E, on dead twig of an unidentified plant, 31 Oct. 2013, C. Chuaseeharonnachai (**Holotype**, BBH 38817).

ETYMOLOGY: The specific epithet refers to the cylindrical shape of the conidia.

Saprobic on dead twig. Asexual morph: COLONIES on natural substratum effuse, brown or black, hairy. MYCELIUM mostly immersed in the substratum, hyphae branched, septate, smooth-walled, pale brown to brown, 1.25–2.5 µm diam. CONIDIOPHORES macronematous, mononematous, unbranched, capitate at the apex (rarely spathulate), cylindrical below, erect, sometimes regenerating at the terminal end with one enteroblastic percurrent extension, 6–10-septate, smooth-walled, brown to dark brown toward the base, 100–227 µm long, 3.75–5 µm diam. at the apex, 7.5–10 diam. at the base (x = 180.16 ×

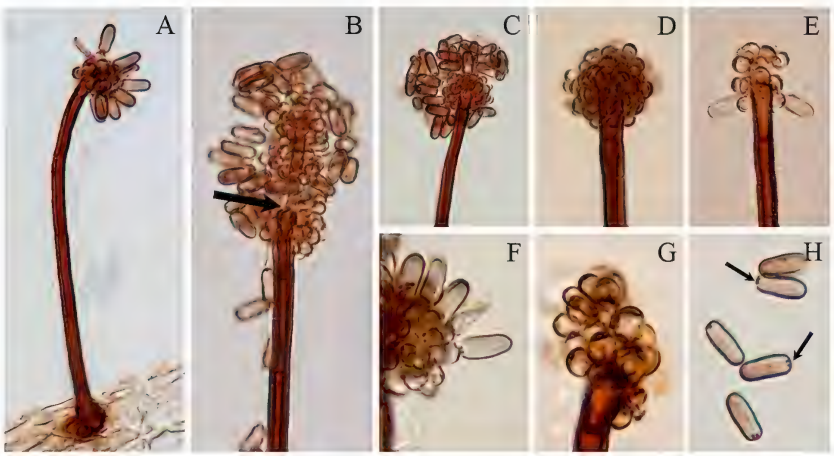

Plate 1. *Tretoheliocephala cylindrospora* (holotype, BBH 38817). A–E. Conidiophores with conidiogenous cells and conidia (the arrow in B indicates regeneration point of the conidiophores); F, G. Conidiogenous cells and conidia. H. Conidia (arrows indicate pore-like detachment scars at the basal end). Scale bars: A, B = 15 µm; C–E = 10 µm; F–H = 5 µm.

4.87 × 8.75 µm; n = 25). Conidiogenous cells monotretic, discrete, globose, determinate, terminal, brown to dark brown, smooth-walled, aggregating within a compact system of globose to subglobose cells (2.5–5 µm diam) to form a capitulum with a diameter of 12.5–32.5 µm. Conidial secession schizolytic. Conidia solitary, oblong or cylindrical with rounded apices, unicellular, dry, brown, smooth-walled with a minute pore-like detachment scar at the basal end, 7.5 × 3 µm (n = 50).

Sexual Morph: Unknown.

Comment—*Tretoheliocephala* was erected by Gusmão & al. (2017), typified by its only species, *T. compacta*. The genus was characterized by macronematous, erect dark brown conidiophores with a compact cluster of globose, monotretic conidiogenous cells that produce solitary or blastocatenate, ovoid, oblong, dolabriform, sub-obpyriform, or obcuneiform, 0–2-septate, brown conidia.

Our new species has features that fit well within the generic description of *Tretoheliocephala*, forming stalked conidiophores with a more or less spherical compact terminal cluster of globose and monotretic conidiogenous cells producing oblong or cylindrical conidia.

Morphologically, *T. cylindrospora* is distinguished from *T. compacta*, which has larger, unbranched conidiophores (320–700 × 15–19 µm) or occasionally

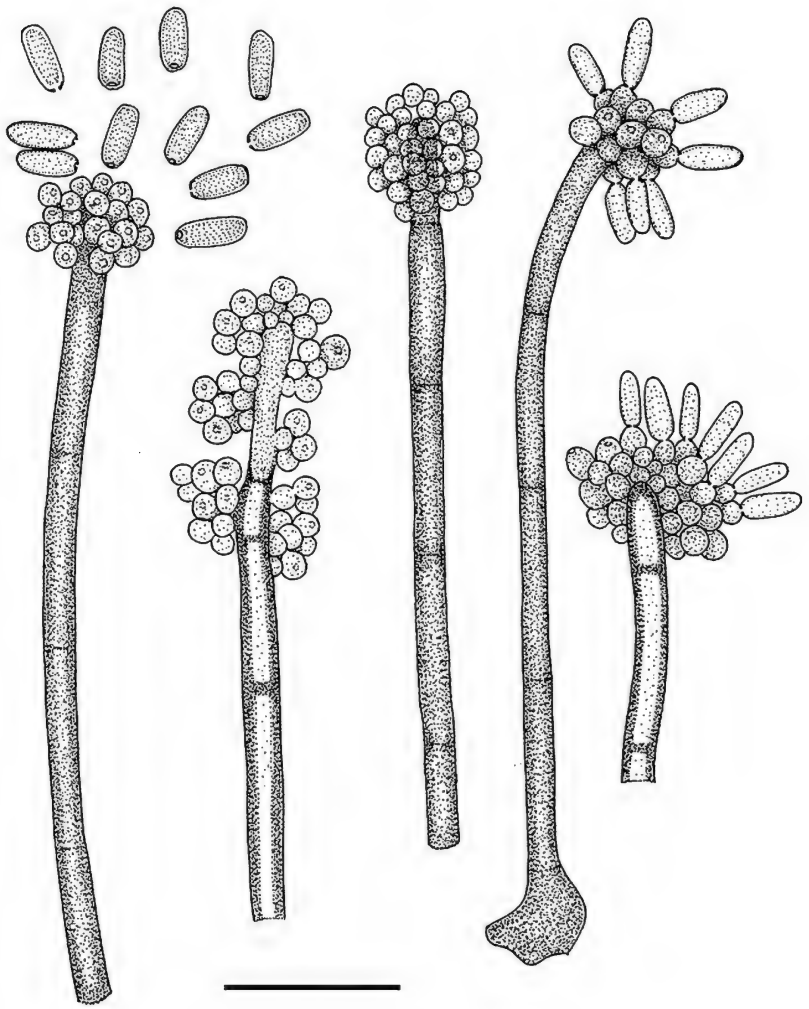

Plate 2. *Tretoheliocephala cylindrospora* (holotype, BBH 38817). Conidiophores, conidiogenous cells, and conidia. Scale bar = 20 µm.

branched conidiophores (200–300 × 13–15 µm), larger conidiogenous cells (8–12 µm diam), and larger morphologically variable, 0–2-septate (mostly 1-septate) conidia (12–21 × 6–7 µm) ranging from ovoid, oblong, dolabriform, subobpyriform to obcuneiform, formed solitarily or blastocatenately (Gusmão & al. 2017).

We regard *T. cylindrospora* as a rare species, in view of the fact that it has been found only once since 2010 during our study of microfungi of Thailand.

Despite several attempts to isolate this fungus onto synthetic media, the new fungus failed to grow on CMA, MEA, PCA, PDA and WA, suggesting that the nutritional requirements in these media may not be enough for germination and viability of the fungus. Thus, we were unable to undertake sequencing of this fungus. Further collections are required to enable culture and sequencing of *Tretoheliocephala* species to determine their taxonomic placement in the *Ascomycota.*

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Novel cyphelloid fungi in *Glabrocyphella*, *Heteroscypha*, and *Rectipilus* from Brazil

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Abstract—New records of cyphelloid fungi from Brazil are presented, based on specimens collected and identified by J. Rick and conserved at Herbarium PACA (São Leopoldo, Rio Grande do Sul). *Glabrocyphella cyathiformis* sp. nov. is characterized by small (0.1–0.5 mm diam.), pale yellow, turbinate basidiomes and ellipsoid to fusoid basidiospores (5–6 × 2–2.5 µm). *Flagelloscypha malmei* is recombined as *Heteroscypha malmei* comb. nov., and *Rectipilus natalensis* is reported for the first time from the Americas. Descriptions, photographs, and illustrations are presented for the three species.

Key words—*Agaricomycetes, Auriculariales, Marasmiaceae,* mycobiota, taxonomy

Introduction

The cyphelloid fungi are an artificial assemblage characterized by basidiomes morphologically similar to the original concept of the genus *Cyphella* Fr. The type species [currently accepted as *Aleurodiscus digitalis* (Alb. & Schwein.) Donk] was originally described as a *Peziza*; indeed, cyphelloid fungi can be characterized as discomycetes with basidia, according to Donk (1966). One difference that can be noted in the field is that discomycetes have their hymenium directed upward, while those of cyphelloid fungi are directed downward, due to differences in the release of spores from asci and basidia.

Cyphelloid fungi have cupulate, discoid, tubular to flattened basidiomes and a smooth to more or less wrinkled hymenophore. Basidiomes are usually less than 1 mm long and grow on litter (grass, leaves, twigs, and other small substrates) and rotten wood. They are externally covered with specialized hyphae, which serve as important characters for circumscribing genera (Donk 1959, Cooke 1961, Agerer 1983, Bodensteiner & al. 2004). According to Agerer (1986), the outer hyphae form the most striking features of cyphelloid basidiomes.

Initially, these fungi were grouped in three genera—*Cyphella*, *Solenia,* and *Porotheleum* (Cooke 1961)—but currently more than 40 diverse genera are recognized for the group (Bodensteiner 2007). Several new cyphelloid species have been based on Brazilian collections (Spegazzini 1889; Hennings 1897, 1908; Rick 1906, 1931, 1959, 1960; Cooke 1961; Singer 1989; Gorjón & Jesus 2014) and a few reports have been published in the past decades (Putzke 2002; Meijer 2006; Sulzbacher & al. 2008, 2009).

During a taxonomical review of cyphelloid type specimens described by J. Rick from Southern Brazil (Trierveiler-Pereira & al. unpubl. data), additional collections of cyphelloid fungi kept at Herbarium PACA (São Leopoldo, Rio Grande do Sul, Brazil) were also examined. Here we present novelties resulting from this research on cyphelloid fungi.

Materials & methods

Dried basidiomes were measured, photographed, and morphologically analyzed. Colors of macrostructures were coded according to Kornerup & Wanscher (1978). For microscopical analyses, basidiomes were hand-sectioned with the aid of a razor blade under a stereoscopic microscope (Agerer 2002). Sections were mounted in distilled water and 3% KOH or 3% KOH with 1% aqueous phloxine to observe and measure the microstructures. The coloring of pigmented elements (e.g., external hyphae and spores) was evaluated in distilled water (Bodensteiner 2007). Amyloid and dextrinoid reactions were tested with Melzer's iodine reagent. Dimensions recorded correspond to the hyphal diameter without crystal covering, spore length without apiculus and basidia without sterigmata.

Taxonomy

Glabrocyphella cyathiformis Trierv.-Per. & Thorn, **sp. nov.** FIG. 1

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Differs from *Glabrocyphella palmarum* by its smaller, turbinate basidiomes and its smaller, subfusiform basidiospores; and from *G. rubescens* by its grayish yellow basidiomes and its narrower, subfusiform basidiospores.

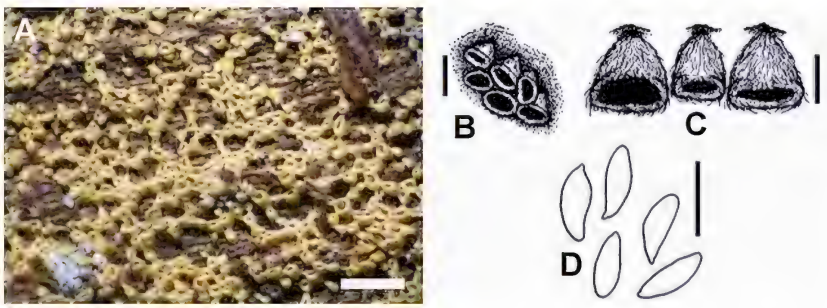

Fig 1. *Glabrocyphella cyathiformis* (PACA 20938, holotype). A. Basidiomes on rotten wood; B, C. Basidiomes in detail; D. Basidiospores. Scale bars: A = 1 mm; B = 0.5 mm; C = 0.3 mm; D = 5 µm.

Type: Brazil, Rio Grande do Sul, Salvador do Sul, 19.IX.1944, J. Rick (**Holotype**, PACA 20938, as *Solenia* sp.)

Etymology: Latin, *cyathiformis*: cup-shaped—slightly wider at the top than at the bottom, referring to the shape of the basidiomes.

Basidiomes clustered in small groups that are in contact, forming a reticulate pattern (rarely scattered), short-cylindrical (when young) to turbinate, 0.1–0.5 mm diam. × 0.3–0.5 mm high; cup margins curving inwards; externally grayish yellow (3B4) to light yellowish (4A4), velvety; hymenium smooth, pastel yellow (1A4). Subiculum absent. Growing on a small piece of rotten wood.

External hyphae adpressed to the surface, some projecting ca 40–100 µm from the basidiome, pale yellow, thick-walled, tortuous, 1–4 µm diam., fibulate, non-dextrinoid and non-amyloid, lacking encrustations or distinctive features, apices round. Subhymenial layer 10–25 µm thick; hyphae agglutinated, hyaline, ca 2 µm diam., fibulate. Hymenial layer 10–15 µm; basidia not seen; basidioles tightly packed together, clavate to short-clavate, hyaline, 9–15 × 4–5 µm, with clamp connections at the base; sterile elements not seen. Basidiospores subfusiform, hyaline, smooth, thin-walled, (4.8–)5–6 × 2–2.5 µm, with a distinct apiculus, non-dextrinoid, non-amyloid.

Ecology & distribution: growing on rotten wood; known only from the type locality.

Additional specimens examined:

Glabrocyphella rubescens: **BRAZIL, Rio Grande do Sul:** São Leopoldo, 1932, J. Rick (PACA 15276, isotype, labeled '*Solenia rubescens* Rick').

***Glabrocyphella palmarum*: BRAZIL, Rio Grande do Sul:** São Leopoldo, 1931, J. Rick (PACA 12863, as *Cyphella palmarum*).

Remarks—*Glabrocyphella* W.B. Cooke included 12 species when introduced by Cooke (1961), and a 13th species, *G. stercoraria* Barrasa & al., has since been proposed.

Glabrocyphella cyathiformis is characterized by turbinate, yellowish basidiomes velvety on the exterior with external hyphae lacking encrustations or any other distinctive feature and without a subiculum and ellipsoid to fusoid hyaline basidiospores [(4.8–)5–6 × 2–2.5 µm].

Glabrocyphella cyathiformis is morphologically close to *G. palmarum* (Berk. & M.A. Curtis) W.B. Cooke, which differs by its ovate to tear-shaped, larger (6–7 × 3–4 µm) basidiospores (Cooke 1961) and larger (≤2 mm high) basidiomes (Burt 1914, as *Cyphella palmarum*). From our examination, Rick's PACA 12863 collection of *G. palmarum* has basidiospores (7.5–)8–9 × 2–3 µm and cupulate-stipitate basidiomes.

Glabrocyphella rubescens Rick ex W.B. Cooke was described based on specimens collected in Southern Brazil. This species is distinguished from *G. cyathiformis* by its cream-colored basidiomes that turn flesh-color upon bruising and its ovoid basidiospores (4.5 × 3.5 µm, Cooke 1961; 5–6 × 3–4 µm, from our examination of the isotype).

Heteroscypha malmei (W.B. Cooke) Trierv.-Per., Baltazar & Thorn, **comb. nov.**

MB 828714 Fig. 2

≡ *Flagelloscypha malmei* W.B. Cooke, Beih. Sydowia 4: 62, 1961.

Basidiomes scattered or mainly in clusters of 2–30 basidiomes, 0.2–0.9 mm diam., cupuliform, external surface yellowish white to pale yellow (1A3, 1A2), tomentose; cup margins hairy, curving inwards; external hairs ca 0.1 mm long; hymenial surface pastel yellow (1A4), smooth. Subiculum absent. Growing on dead palm tree (peduncular bract).

External hyphae (hairs) 100–140 × 2–4 µm, hyaline to pale yellow, more pigmented towards the base, thick-walled with narrow lumen, non-dextrinoid and non-amyloid, encrusted with acicular ≤4 µm long crystals; apical end flagelliform, smooth, 20–40 µm long. Subhymenial layer ca 15 µm thick; hyphae agglutinated, hyaline, ca 2 µm diam. Hymenial layer ca 25 µm; basidia short clavate, hyaline, 15–22 × 4–6 µm, with clamp connection at the base, 4-sterigmate, longitudinally septate at the apex; sterile elements (leptocystidia) observed in the hymenial layer, especially near the margins, tortuous, hyaline, smooth, ca 40 × 4 µm. Basidiospores fusoid to asymmetrical-ellipsoid, hyaline, smooth, thin-walled, (7.5–)8–10 × (3.5–)4.0–4.5 µm, Q = 2.2 (n = 13), with a distinct apiculus, some germinating with hyphae, non-dextrinoid, non-amyloid; some adhering in groups of 3–4.

Fig 2. *Heteroscypha malmei* (PACA 12865). A. Basidiomes on rotten wood; B. Basidiospores; C. Basidioles and basidia; D. External hyphae; E. Hymenial sterile elements. Scale bars: A = 1 mm; B–E = 10 µm.

Specimen examined: **BRAZIL. Rio Grande do Sul:** Salvador do Sul, 1943, J. Rick (PACA 12865, as *Cyphella palmarum*).

Ecology & distribution: growing on rotten wood; known only from Southern Brazil, State of Rio Grande do Sul, from the municipalities of Santo Angelo (holotype of *Flagelloscypha malmei*; Cooke 1961) and São Salvador (this study).

Remarks—In the examined material, the hymenial layer of most of the basidiomes has been eaten by insects and only the external layer and hairs remain, therefore, few basidia and basidiospores were observed.

Heteroscypha Oberw. & Agerer was proposed as a monotypic genus, typified by *Cyphella applanata* [≡*H. applanata* (P.H.B. Talbot) Oberw. & Agerer]; detailed illustrations and description of the type specimen were presented, showing the apically septate basidia (Agerer & Oberwinkler 1979). *Heteroscypha malmei* was previously considered a member of *Flagelloscypha* Donk, since the external hairs have acicular crystal encrustations, with the exception of the flagelliform apical end (Cooke 1961).

Our Brazilian specimen of *H. malmei* has slightly longer basidiospores with a Q ratio higher compared with those previously described for *F. malmei* (8–9 × 4–5 µm, Cooke 1961; 7.5–8.5 × 4–5 µm, Q = 1.7, Agerer & Oberwinkler 1979). *Heteroscypha applanata* differs from *H. malmei* by its white, discoid-petaliform basidiomes, its thin-walled external hairs, its fully septate basidia, and

its longer basidiospores (9–12.6 × 3.2–5.4 µm, Cooke 1961; 8–10 × 4–5 µm, Q = 2.1, Agerer & Oberwinkler 1979).

Rick's PACA 12865 collection of *Heteroscypha malmei* was labelled *Cyphella palmarum*; however *Glabrocyphella palmarum* differs from *H. malmei* by its holobasidia, its larger (≤3 mm diam.) hairless cups, and its smaller basidiospores (Cooke 1961).

As indicated by Agerer & Oberwinkler (1979), additional fresh materials of these species suitable for cultural, ultrastructural, and molecular studies are highly desirable.

Rectipilus natalensis (W.B. Cooke) Agerer, Persoonia 7(3): 425, 1973. FIG. 3

BASIDIOMES agglutinated, tubuliform, long, 0.5–1.0 mm high; 0.1–0.3 mm diam.; externally light orange (5A5) to grayish yellow (4B4) covered by scattered whitish hyphae, pale yellow near the margins (2A3); margins hairy; hymenium light orange (5A4, 5A5), smooth. Subiculum absent. Growing on small pieces of wood.

EXTERNAL HYPHAE compact, closely adpressed to the surface of the basidiome, pale yellow, thick-walled, not encrusted, 2–3 µm diam., clamp connections present, hyphal tips coiled and twisted near the margins, non-dextrinoid and non-amyloid. SUBHYMENIAL LAYER 10–20 µm thick; hyphae agglutinated, pale yellow, ca 2 µm diam. HYMENIAL LAYER 15–20 µm; basidioles yellowish, basidia clavate, 10 × 4 µm, 4-sterigmata, with clamp connection at the base; sterile elements not seen. BASIDIOSPORES globose to subglobose, hyaline, smooth, 3–4(–4.5) × 2.2–3 µm, non-dextrinoid, non-amyloid.

SPECIMEN EXAMINED: **BRAZIL. RIO GRANDE DO SUL**: Salvador do Sul, 9.IX.1944, J. Rick (PACA 22683, as *Solenia* sp.).

ECOLOGY & DISTRIBUTION: growing on rotten wood; known from Southern Africa (Talbot 1956, as *Solenia natalensis*) and Southern Brazil (this study).

REMARKS–*Rectipilus* Agerer contains eleven species (Lucas & Dentinger 2015). Gorjón & Jesus (2014) provided an identification key to nine of these species.

Rectipilus natalensis is characterized by cylindrical, tubuliform basidiomes with external hairs from the upper portions with spirally coiled apices, the lack of subiculum, and small, globose to subglobose, hyaline basidiospores. The original basionym description (Talbot 1956, as *Solenia natalensis*) indicates basidiomes up to 2 mm long, but the Brazilian basidiomes are shorter (up to 1 mm long). Agerer (1973) described the holotype as yellowish, while the Brazilian material has pale orange external surface and is yellowish only near the upper part of the basidiome.

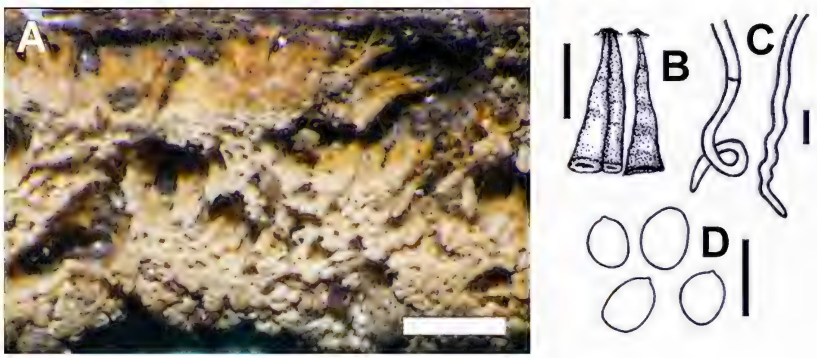

Fig 3. *Rectipilus natalensis* (PACA 22683). A. Basidiomes on rotten wood; B. Basidiomes in detail; C. External hyphal tips; D. Basidiospores. Scale bars: A = 1 mm; B = 0.5 mm; C = 5 µm; D = 10 µm.

Agerer (1973) stated that *R. confertus* (Burt) Agerer and *R. fasciculatus* (Pers.) Agerer are similar to *R. natalensis*, but they lack external hyphae with twisted or coiled apices, and they present different basidiospore morphologies. The only *Rectipilus* species previously reported from Brazil, *R. stromatoides* Gorjón, differs from *R. natalensis* by its basidiomata, which are arranged in a dense, broadly effused, vivid pink stroma (Gorjón & Jesus 2014).

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New species of *Marthamyces* and *Ramomarthamyces* gen. nov. from New Zealand and the Cook Islands

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Abstract—A leaf-spotting fungus common on *Phormium tenax* in New Zealand is described here as *Marthamyces harakeke* sp. nov. The phylogenetic analysis prepared for the description of this new species showed *Marthamyces* to be polyphyletic. To resolve this, three *Marthamyces* species from Australia and New Zealand, *M. barbatus*, *M. dracophylli*, and *M. gilvus*, are recombined in the new genus *Ramomarthamyces*. Morphologically the *Ramomarthamyces* species differ from *Marthamyces* in having paraphyses distinctly branched, rather than propoloid. A fungus common on recently fallen leaves of *Metrosideros* spp. in New Zealand has been previously referred to as *Marthamyces emarginatus*, but is recognised here as a new species, *Marthamyces metrosideri*. In addition, two new *Marthamyces* species, *M. maccormackii* on *Metrosideros collina*, and *M. renga* on *Metrosideros collina*, *Vaccinium cereum*, and *Weinmannia samoensis*, are described from the Cook Islands, and a new *Ramomarthamyces* species, *R. tuku* on *Juncus* sp., is described from New Zealand. Finally, *Naemacyclus culmigenus* is recombined in *Marthamyces*.

Key words—fungi, *Leotiomycetes*, *Marthamycetaceae*, New Zealand flax, pathogen

Introduction

A leaf-spotting fungus common on *Phormium tenax* J.R. Forst. & G. Forst. (*Asphodelaceae*) in New Zealand has been tentatively referred to as *Propolis* sp. in the literature (McKenzie & al. 1999) and on the NZFungi website (https://nzfungi2.landcareresearch.co.nz). Macroscopically the fungus recalls *Propolis* and *Marthamyces* in having ascomata immersed in host tissue, opening by several irregular slits, and the hymenial surface having

a crystalline appearance when the flaps of covering host tissue fold back. It is distinguished from most *Marthamyces* species in having bifusiform to trifusiform ascospores and in being pathogenic, but neither of these features is unique in the genus. Ascospore shape is variable in these fungi; e.g., *Marthamyces desmoschoeni* and *M. dendrobii* have swollen areas along their filiform ascospores. A pathogen of *Miscanthus* (*Poaceae*), identified as *Naemacyclus culmigenus* by Hosoya & al. (2013), is morphologically typical of *Marthamyces*, and also matches the genus *Marthamyces* phylogenetically, based on the molecular phylogenetic analysis provided in this paper.

DNA sequencing of other *Marthamyces* specimens from New Zealand, the Cook Islands, and Australia revealed several other taxonomic issues. Species placed in *Marthamyces* by Johnston (1986, 2006) separate into two distinct clades, one of which contains the type species of *Marthamyces*, *M. emarginatus*. The clade that does not contain *M. emarginatus* is segregated here into a newly described genus, *Ramomarthamyces*. Three new *Marthamyces* species are proposed, one for specimens collected from *Metrosideros excelsa* Sol. ex Gaertn., *M. fulgens* Sol. ex Gaertn., *M. kermadecensis* W.R.B. Oliv., *M. robusta* A. Cunn., and *M. umbellata* Cav. (*Myrtaceae*) in New Zealand, a second from *Metrosideros collina* (J.R. Forst. & G. Forst.) A. Gray on the Cook Islands, and a third from *M. collina*, *Vaccinium cereum* G. Forst. (*Ericaceae*) and *Weinmannia samoensis* A. Gray (*Cunoniaceae*) on the Cook Islands. A new *Ramomarthamyces* sp. is described from *Juncus* in New Zealand.

Materials & methods

The *Marthamyces* specimens studied were collected from native forests in New Zealand, the Cook Islands, and Australia. Those maintained in culture were grown from ascospores germinating on water agar plates at the time the specimens were collected. The fungarium specimens are deposited in PDD, and the living cultures in the ICMP culture collection, with both collections maintained by Manaaki Whenua – Landcare Research, Auckland (https://scd.landcareresearch.co.nz/).

DNA extraction, amplification, and sequencing followed the methods of Johnston & Park (2005). Amplification primers were ITS1F and ITS4 for ITS (White & al. 1990, Gardes & Bruns 1993), LROR and LR5 for LSU (Bunyard & al. 1994, Vilgalys & Hester 1990), NS1 and NS4 for SSU (White & al. 1990), and mrSSU1 and mrSSU3R for mtSSU (Zoller & al. 1999).

DNA sequences from the newly collected specimens were added to those available for SSU, ITS, LSU, and mtSSU from the *Leotiomycetes* taxa treated in a class-wide, 15-gene phylogeny (Johnston & al. 2019) that were not members of the order *Helotiales*. Each gene was aligned using MAFFT (Katoh & Standley 2013) as

TABLE 1. Specimens and GenBank accession numbers for the DNA sequences used for specimens of *Marthamycetaceae* in FIGS 1 and 2. Other specimens and sequences in FIGS 1 and 2 are from Johnston et al. (2019) [available through Manaaki Whenua Datastore, https://doi.org/10.7931/T5YV-BE95].

SPECIES	VOUCHER	COUNTRY	HOST	SSU	ITS	LSU	MTSSU
'Coccomyces proteae'	CBS 111703/ CBS 111704	South Africa	*Protea* sp.	—	JN712451/ JN712450	JN712515	—
	CR252M	Puerto Rico	*Disterigma humboldtii*	—	JX089385	—	—
Cyclaneusma minus	CBS 496.73	Chile	*Pinus radiata*	FJ176812	NR_153910	FJ176868	FJ190629
	ICMP 17358	New Zealand	*Pinus radiata*	KJ606669	KJ606680	KJ606674	MH698452
Marthamyces culmigenus	TNS F-41728	Japan	*Miscanthus sinensis*	—	AB745435	AB745437	AB745436
Marthamyces desmoschoeni	ICMP 17350	New Zealand	*Desmoschoenus spiralis*	KJ606670	KJ606679	KJ606673	—
Marthamyces emarginatus	ICMP 22854	Australia	*Eucalyptus* sp.	MK681769	MH921869	MK599203	MK598751
	ICMP 22622	Australia	*Eucalyptus* sp.	—	MK599209	—	—
	ICMP 22623	Australia	*Eucalyptus* sp.	—	MK599210	—	—
Marthamyces cf. *emarginatus*	ICMP 22628	Australia	*Eucalyptus* sp.	—	MK599211	—	v
	ICMP 22621	Australia	*Eucalyptus* sp.	MK681770	MK599212	MK599204	MK598752
Marthamyces harakeke	PDD 108765	New Zealand	*Phormium tenax*	MK681771	MK599213	MK599205	MK598753
Marthamyces maccormackii	ICMP 16155	Cook Islands	*Metrosideros collina*	—	MK599215	—	—
	ICMP 15831	Cook Islands	*Metrosideros collina*	—	MK599216	—	—
	ICMP 15829	Cook Islands	*Metrosideros collina*	—	MK599217	—	—

Species	Voucher	Country	Host	SSU	ITS	LSU	mtSSU
Marthamyces metrosideri	ICMP 17398	New Zealand	*Metrosideros robusta*	MH682226	MH682227	HM140558	HM143831
	ICMP 22625	New Zealand	*Metrosideros robusta*	—	MK599218	—	—
	PDD 111232	New Zealand	*Metrosideros excelsa*	—	MK599219	—	—
	ICMP 22624	New Zealand	*Metrosideros robusta*	—	MK599220	—	—
Marthamyces quadrifidus	ICMP 18329	New Zealand	*Weinmannia racemosa*	MK681772	MK599214	HM140559	HM143832
Marthamyces renga	ICMP 15830	Cook Islands	*Metrosideros collina*	—	MK599221	—	—
	ICMP 15827	Cook Islands	*Metrosideros collina*	—	MK599222	—	—
Mellitiosporium versicolor	Lantz357 (UPS)	Sweden	—	—	—	HM140560	—
Naemacyclus fimbriatus	CBS 289.61	Switzerland	*Pinus* sp.	FJ176811	—	FJ176867	—
	CBS 440.71	Spain	*Pinus* sp.	—	MH860208	—	—
Propolis farinosa	ICMP 17354	New Zealand	—	MH682223	MH682229	HM140562	HM143834
Propolis versicolor	ILLS 60497	USA	—	—	JQ256425	JN012015	—
Ramomarthamyces barbatus	ICMP 22853	Australia	*Eucalyptus* sp.	MK681773	MH921868	MK599206	MK598749
	ICMP 22620	Australia	*Eucalyptus* sp.	—	MK599223	—	—
	ICMP 22627	Australia	*Eucalyptus* sp.	—	MK599224	—	
Ramomarthamyces dracophylli	ICMP 17381	New Zealand	*Dracophyllum sinclairii*	MH698450	MH682228	MK599207	MH698450
Ramomarthamyces gilvus	ICMP 22855	Australia	*Caustis* sp.	—	MH921870	—	—
	ICMP 22626	Australia	*Lepidosperma laterale*	—	MK599225	—	—
Ramomarthamyces tuku	ICMP 22562	New Zealand	*Juncus* sp.	—	MK599226	MK599208	MK598750

implemented in Geneious 10, the ends were manually trimmed and introns were removed as necessary, and then the alignments were concatenated. Maximum likelihood analyses were run with IQ-TREE (Nguyen & al. 2015, Chernomor & al. 2016) using models selected by ModelFinder using the BIC criterion (Kalyaanamoorthy 2017) for each partitioned gene; branch support was estimated using ultrafast bootstrap analysis with 1000 replicates (Hoang & al. 2018). *Xylaria hypoxylon* and *Neurospora crassa* were used as outgroup. We also performed an ITS analysis, which included additional specimens of each species as well as DNA sequences from two GenBank accessions of *Marthamyces* specimens identified incorrectly as *Coccomyces proteae*. The ITS analysis used the same methods as the multi-gene analysis but included only the *Marthamycetaceae* specimens together with the *Chaetomellaceae* specimens treated by Johnston & al. (2019), *Chaetomellaceae* being sister to *Marthamycetaceae* in the Fig. 1 multigene analysis. The *Marthamycetaceae* taxa and genes included in the phylogenetic analyses are provided in Table 1.

Phylogeny

The higher-level taxa resolved with our four-locus analysis (SSU, ITS, LSU, and mtSSU; Fig. 1) matched those in the more data-rich analysis of Johnston & al. (2019). The monophyletic *Marthamycetaceae* included *Mellitiosporium, Propolis, Cyclaneusma, Naemacyclus,* and *Marthamyces*. Species previously named as *Marthamyces gilvus, M. barbatus,* and *M. dracophylli* formed a clade separate from the clade containing the type species of *Marthamyces,* and these species are recombined below in a new genus, *Ramomarthamyces*. A specimen identified by Hosoya & al. (2013) as *Naemacyclus culmigenus* is strongly supported as a member of the *Marthamyces* sensu stricto clade, and this species is recombined in *Marthamyces* below. Two *Marthamyces emarginatus*-like specimens collected from *Eucalyptus* leaves in Australia are phylogenetically distinct from each other, and from *M. emarginatus* as accepted here, but are not formally named as new species because each is known from only a single specimen. The *M. emarginatus*-like species from *Metrosideros* in New Zealand is recognised as a new species, described below as *M. metrosideri*.

The ITS gene tree (Fig. 2) includes additional specimens of several of the accepted species. It also includes three accessions in GenBank deposited as *Coccomyces proteae* that are misidentifications of *Marthamyces* spp. The position of *Naemacyclus fimbriatus* differs between the two trees; clarification of its relationship requires additional genes or the sampling of additional species within *Naemacyclus*.

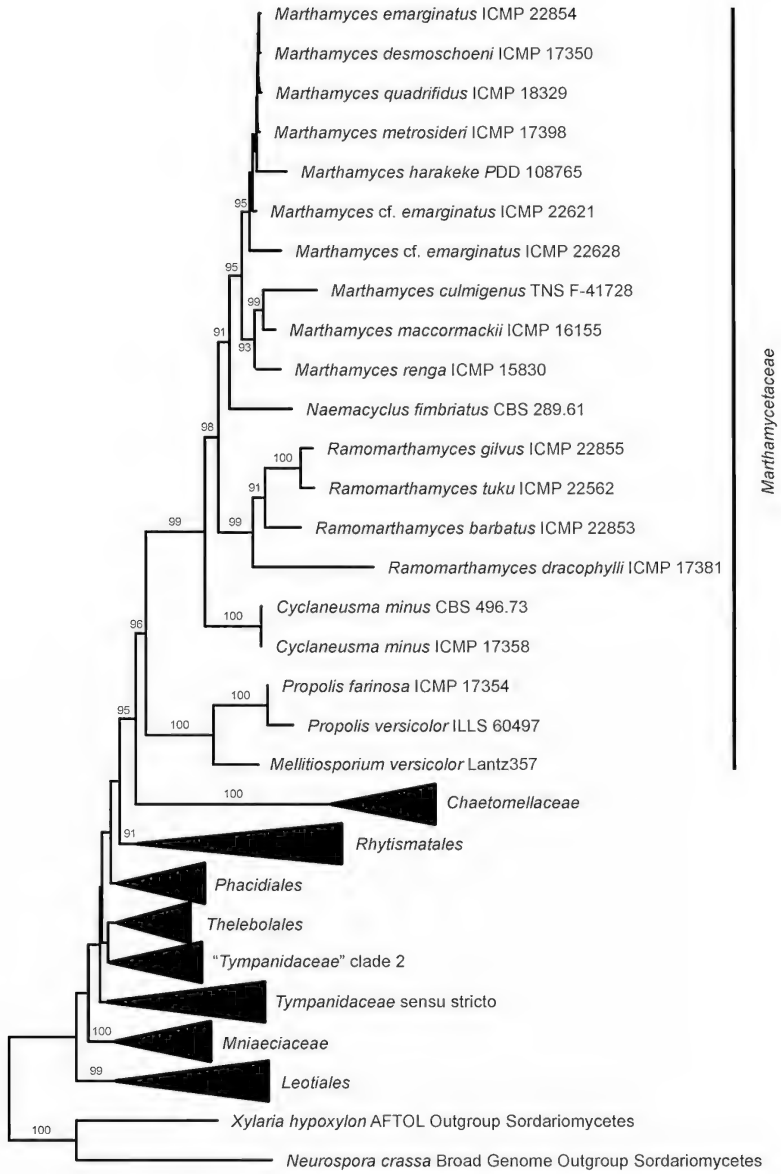


FIGURE 1. ML tree based on concatenated SSU, ITS, LSU, and mtSSU sequences, with bootstrap values shown when >90%. Details of the specimens of *Marthamycetaceae* included in the analysis are provided in TABLE 1; the extra-limital taxa in other families and orders are from Johnston et al. (2019) and their data are available though the Manaaki Whenua – Landcare Research Datastore (https://doi.org/10.7931/T5YV-BE95).

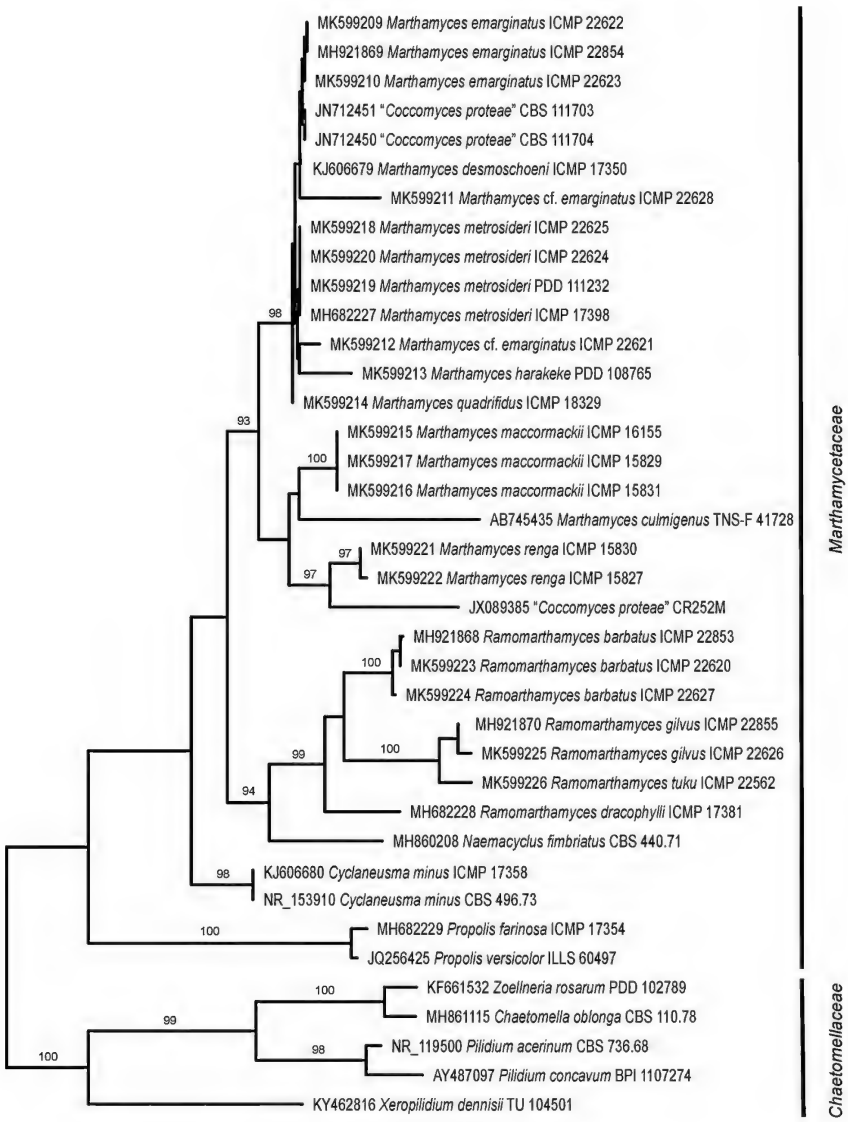


FIGURE 2. ML tree based on ITS sequences with bootstrap values shown when >90%. Details of the specimens of *Marthamycetaceae* included in the analysis are provided in TABLE 1. Members of the *Chaetomellaceae*, sister to *Marthamycetaceae* in the multi-gene analysis in FIG. 1, are used as the outgroup; data for the outgroup specimens are available through the Manaaki Whenua – Landcare Research Datastore (https://doi.org/10.7931/T5YV-BE95).

Taxonomy

Marthamyces culmigenus (Ellis & Everh.) P.R. Johnst., **comb. nov.**

IF 556322

≡ *Naemacyclus culmigenus* Ellis & Everh., Proc. Acad. Nat. Sci. Philadelphia 45: 151, 1893.

Notes: The combination is based on both DNA sequence and morphological data. The description of *Naemacyclus culmigenus* from Hosoya & al. (2013) cites the morphological features typical of *Marthamyces* with respect to ascomatal wall structure, the 0–1-septate filiform ascospores, and propoloid paraphyses. *Naemacyclus fimbriatus*, a heterotypic synonym of *N. pinastri*, the type species of *Naemacyclus*, differs in having unusually long periphysoids lining the upper wall of the opened ascoma, and also differs in having multi-septate ascospores and paraphyses simple at the apex (DiCosmo 1979). A specimen identified as *N. fimbriatus* (AFTOL ID-1295, CBS 289.61; Fig. 1) is phylogenetically distinct from the specimen accepted as *N. culmigenus* by Hosoya & al. (2013).

Marthamyces emarginatus (Cooke & Massee) Minter, Mycotaxon 87: 51, 2003. Fig. 3

≡ *Stictis emarginata* Cooke & Massee, Grevillea 18: 7, 1889.

≡ *Propolis emarginata* (Cooke & Massee) Sherwood, Mycotaxon 5: 323, 1977.

Specimens examined—**AUSTRALIA**: **Victoria**: on *Eucalyptus* sp., Martin 439 (K – holotype of *Stictis emarginata*). **Tasmania**: Mt Wellington, on *Eucalyptus* sp., 4 Oct 1997, coll. P.R. Johnston AU97-7 (PDD 81847, duplicate HO, culture ICMP 22621); Cradle Mountain Lake St Clair National Park, Cynthia Bay–Shadow Lake Track, near Watersmeet, on *Eucalyptus* sp., 7 Oct 1997, coll. P.R. Johnston AU97-64 (PDD 81844, duplicate HO, culture ICMP 22623); Cradle Mountain Lake St Clair National Park, Cynthia Bay–Echo Point Track, on *Eucalyptus* sp., 8 Oct 1997, coll. P.R. Johnston AU97-84 (PDD 81845, duplicate HO, culture ICMP 22622); Zeehan–Wynyard road, Hellyer Gorge State Reserve, on *Eucalyptus* sp., 12 Oct 1997, coll. P.R. Johnston AU97-123 (PDD 81846, culture ICMP 22854). **New South Wales**: New England National Park, Point Lookout, Lyrebird Walk, on *Eucalyptus* sp., 31 May 1996, coll. P.R. Johnston AU96-211-2 (PDD 81848, culture ICMP 22628).

Notes: Originally described from fallen *Eucalyptus* leaves from Australia, this species has been reported from *Eucalyptus* from the Canary Islands, North America, and South Africa (Sherwood 1977, Crous & van der Linde 1993). It was first reported from New Zealand by Johnston (1986), but on *Metrosideros* rather than *Eucalyptus*, and it has not subsequently been reported on *Eucalyptus* from New Zealand (Dick 1990, https://nzfungi2.landcareresearch.co.nz, accessed 10 October 2018). Here we accept *M. emarginatus* as a specialist of *Eucalyptus*, and the *Metrosideros*-inhabiting fungus from New Zealand is described below as a new species.

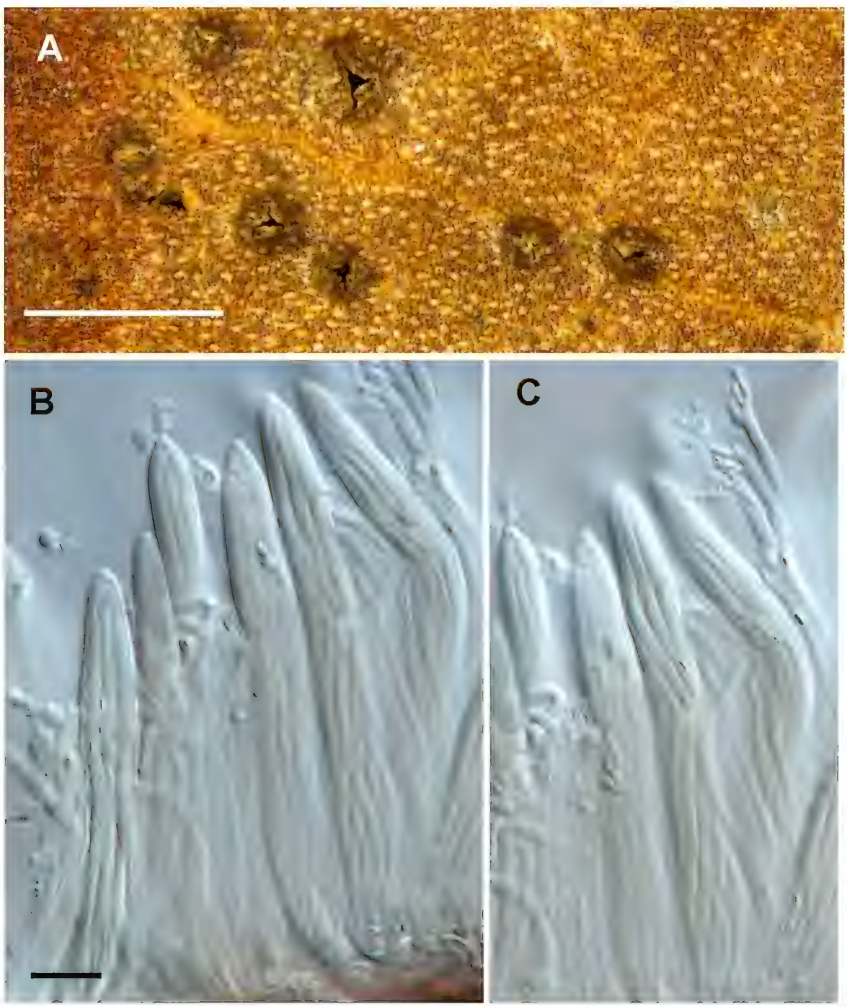


FIGURE 3. *Marthamyces emarginatus* (A. PDD 81846; B, C. PDD 81845). A. Macroscopic appearance when dry; B. Asci with rostrate apex; C. Propoloid paraphyses. Scale bars: A = 1 mm; B, C = 10 µm.

The *Marthamyces* specimens examined from fallen *Eucalyptus* leaves from Australia are similar in macro- and micro-morphology, but phylogenetically they form three groups, each probably representing a distinct species. PDD 81844 (ICMP 22623), PDD 81845 (ICMP 22622), and PDD 81846 (ICMP 22854) have almost identical ITS sequences and are morphologically more or less indistinguishable. PDD 81848 (ICMP 22628) and the three-specimen

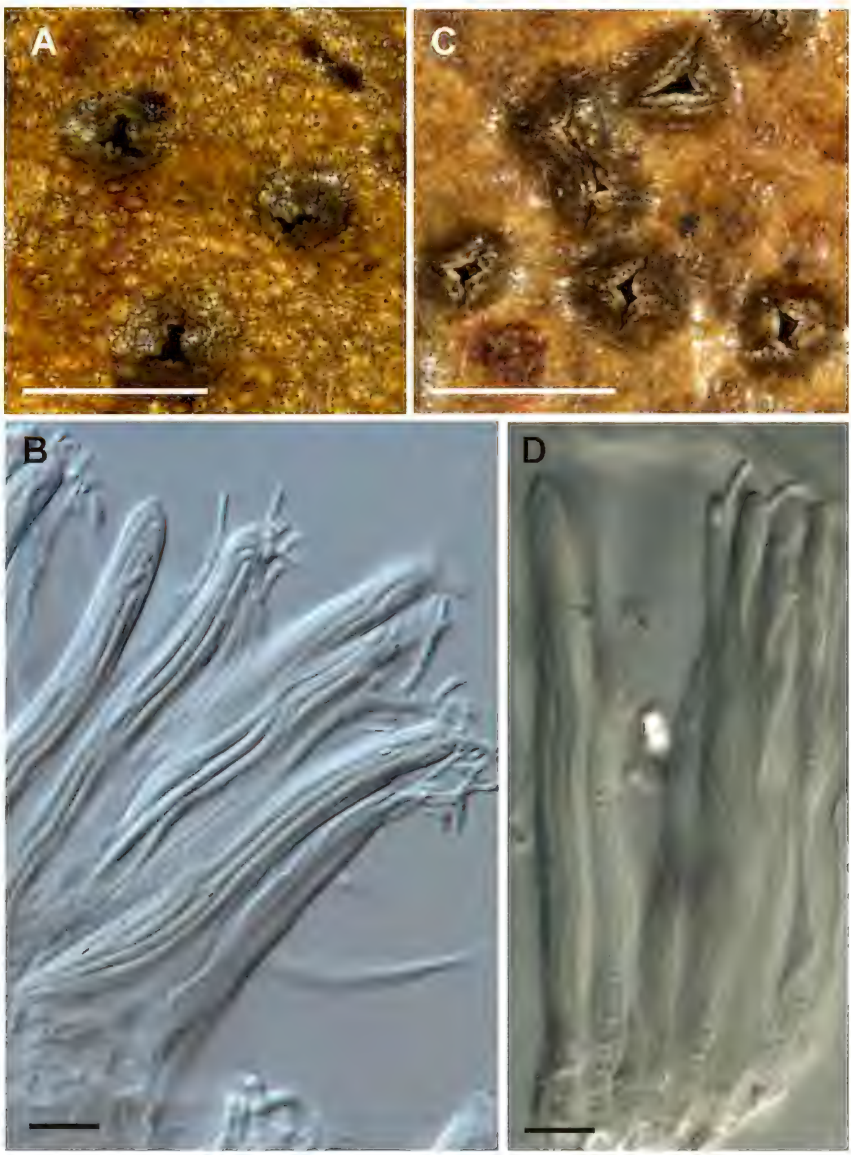


Figure 4. *Marthamyces* cf. *emarginatus* (A, B. PDD 81848; C, D. PDD 81847). A. Macroscopic appearance when dry; B. Apex of paraphyses with several long apical branches; C. Macroscopic appearance when dry; D. Paraphyses broad, sometimes with single narrow branch at apex. Scale bars: A, C = 0.5 mm; B, D = 10 μm.

group cited above share 92% identical sites across the ITS region; PDD 81848 differs morphologically in having longer, finger-like extensions at the ends of the propoloid paraphyses (Fig. 4A, B). PDD 81847 (ICMP 22621) and the three-specimen group cited above share 96% identical sites across the ITS region; PDD 81847 differs morphologically in having darker ascomata and paraphyses that are broader near the apex and typically with a single, finger-like projection (Fig. 4C, D). Here we provisionally accept the three matching specimens PDD 81844, PDD 81845, and PDD 81846 as *M. emarginatus*. No epitype is proposed because no recent specimens are available from Victoria, the type locality of *M. emarginatus*.

Marthamyces harakeke P.R. Johnst., **sp. nov.** Figs 5, 6

IF 556323

Differs from *Marthamyces emarginatus* by its *Phormium* host preference, by its fruiting on living leaves, by its ascomata being elongate, and by its broader, bifusiform to trifusiform ascospores.

Type: New Zealand: Auckland: Waitakere Ranges, Kaitarakihi Beach, on *Phormium tenax* living leaves, 20 July 1983, coll. P.R. Johnston R328 (**holotype** PDD 112252).

Etymology: harakeke, Māori name for the host.

Ascomata and conidiomata developing on living leaves within reddish, elliptic to fusiform, approximately 10–30 × 3–15 mm lesions. Ascomata more or less cylindric, 0.6–2 × 0.3–0.5 mm, concolorous with host tissue, immersed, initially with covering host tissue becoming slightly raised, then the covering host tissue splitting irregularly, the flaps of tissue folding back to expose the hymenial surface, which has a pale yellow, crystalline appearance. Undersides of flaps of host tissue also with crystals. Ascomata subepidermal, in vertical section upper wall up to 40 µm thick, comprising several layers of non-gelatinous tangled hyphae about 4–5 µm diam., with cell walls thin, pale brown, lined with a layer of periphysoids, cylindric, unbranched, 15–20 × 3–6 µm, hyaline. Periphysoids downward projecting before ascomata open, inward projecting after ascomata open, partly lost after opening. Lower wall and subhymenium 15–20 µm thick, lower wall comprising tangled hyphae 2–3 µm diam., with cell walls thin, pale brown. Paraphyses 3–4 µm diam., simple or with one or more short, tapering, narrow, 1.5–2 µm diam. branches at apex, extending about 10–20 µm beyond asci, small crystals in clumps amongst the parts of the paraphyses above the asci. Asci 110–180 × 12–14 µm, cylindric, apex broadly rounded, wall undifferentiated or slightly thinner across the apex, 8-spored. Ascospores 55–78 × 3.5–4.5 µm (1.5–2.5 µm at the constrictions), long-cylindric,

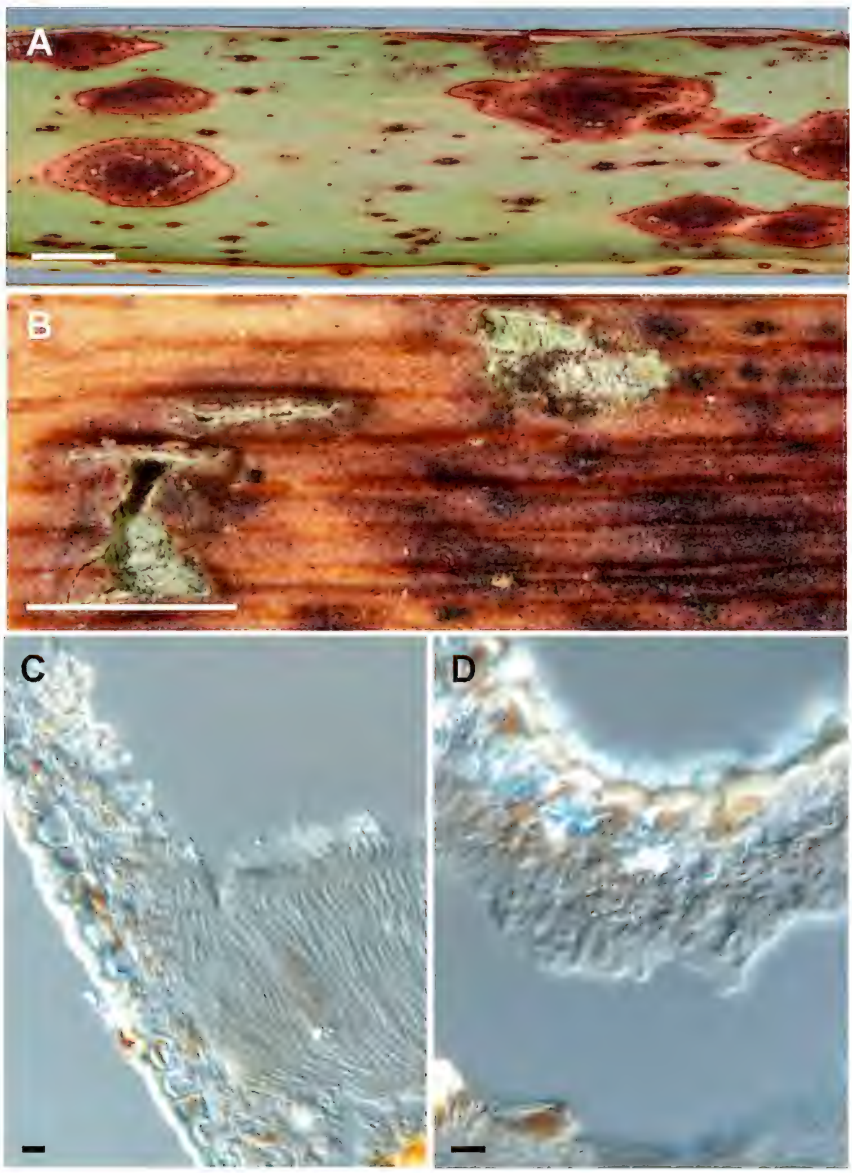


Figure 5. *Marthamyces harakeke* (A, B. PDD 108765; C, D. PDD 112252). A, B. Macroscopic appearance when dry; C. Upper wall of ascoma and part of hymenium in vertical section; D. Detail of upper wall of immature, unopened ascoma showing periphysoid layer. Scale bars: A = 1 cm; B = 1 mm; C, D = 10 μm.

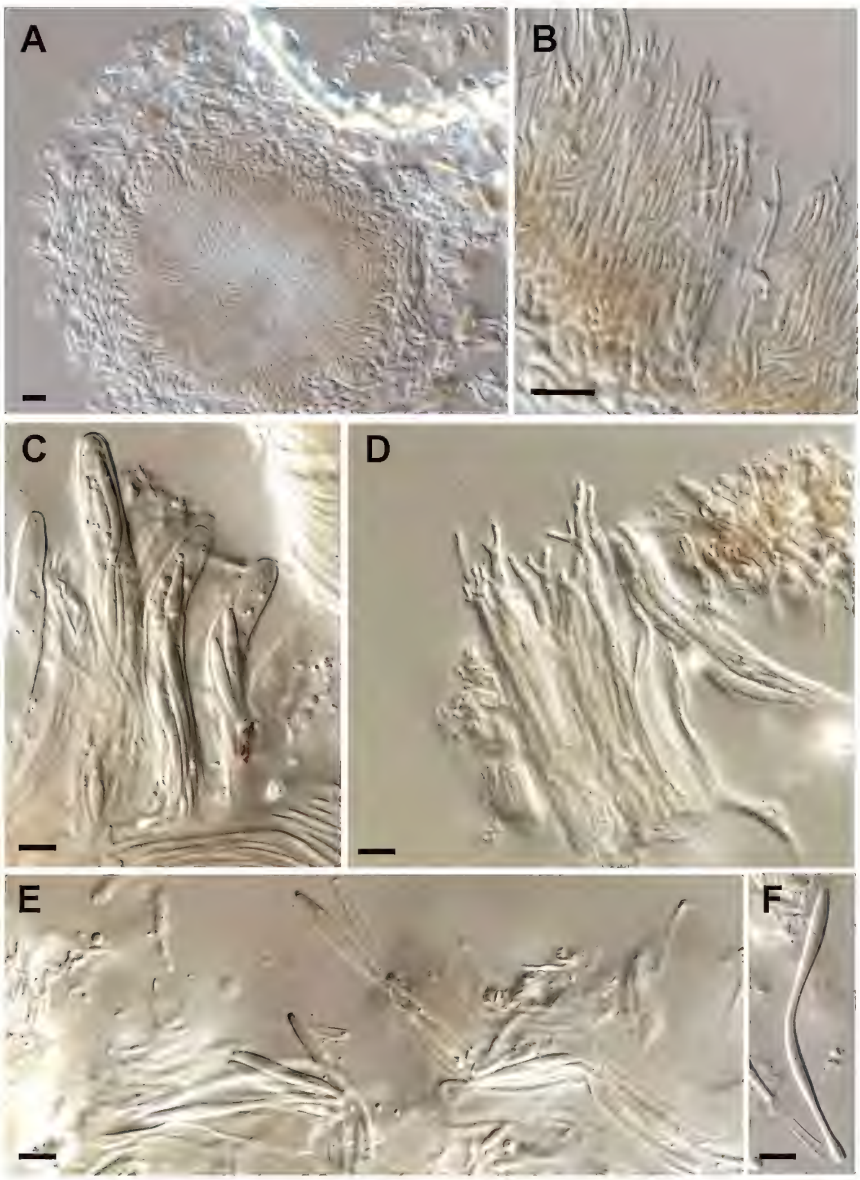


Figure 6. *Marthamyces harakeke* (A, B. PDD 112252; C–F. PDD 108765). A. Conidioma in vertical section; B. Wall of conidioma, conidiogenous cells, and conidia; C. Asci and ascospores; D. Apex of paraphyses; E, F. Ascospores with small globose gel caps at each end. Scale bars = 10 μm.

trifusiform with two constrictions along the length (rarely bifusiform with a single constriction), a single septum at the upper constriction, small, globose gelatinous caps at each end, hyaline. Conidiomata developing within leaf spots prior to the mature ascomata, immersed in host tissue, host tissue darker around the conidiomata, conidiomata globose, opening by a small, round pore through stomata, conidiomatal wall about 10 µm thick, comprising 5–6 layers of tangled hyphae 1.5–2.5 µm diam. with walls hyaline, thin. Wall near the opening of the conidioma up to 20 µm thick, comprising hyphae up to 6 µm diam., innermost cells lining the ostiole slightly elongated and periphysoid-like. Conidiomatal wall lined with conidiogenous layer. Conidiogenous cells 10–17 × 1.5–2 µm, cylindric, tapering slightly towards the barely differentiated apical conidiogenous locus; several conidiogenous cells held on a conidiophore, cylindric, 8–12 × 2–2.5 µm, hyaline. Conidia 16–24 × 0.8–1 µm filiform, straight to irregularly curved, 0–septate, hyaline.

Additional specimens examined—**NEW ZEALAND**: **Auckland**: Hauraki Gulf, Tiritiri Matangi Is., Ridge Track, on *Phormium tenax* living leaf, 28 Oct 2000, coll. E.H.C. McKenzie, R.E. Beever REB1978 (PDD 83472); Tiritiri Matangi Island, on *Phormium tenax* living leaf, 27 Oct 2000, coll. P.R. Johnston R1017 (PDD 72007); Piha, on *Phormium tenax* living leaf, 5 Oct 1972, coll. J.M. Dingley (PDD 60494); Piha, on *Phormium tenax* living leaf, 2 Apr 1956, coll. J.M. Dingley (PDD 60497); Piha, on *Phormium tenax* living leaf, 5 Sep 1960, coll. J.M. Dingley (PDD 60500); Piha, on *Phormium tenax* living leaf, Sep 1960, coll. R.F.R. McNabb (PDD 43290); Piha, on *Phormium tenax* living leaf, 5 Oct 1972, coll. J.M. Dingley (PDD 43312); Waitakere Swamp, on *Phormium tenax* living leaf, 3 Apr 1964, coll. J.M. Dingley (PDD 23268); Karekare, on *Phormium tenax* living leaf, 27 Apr 1971, coll. J.M. Dingley (PDD 60495); Anawhata, on *Phormium tenax* living leaf, 13 May 1972, coll. J.M. Dingley (PDD 60498). **Chatham Islands**: Rekohu, Rangaika Reserve, on *Phormium tenax* living leaf, 21 Nov 1992, coll. E.H.C. McKenzie, P.R. Johnston C80 (PDD 62689). **Coromandel**: Little Barrier Island, near East Cape, on *Phormium tenax* living leaf, 16 June 1984, coll. R.E. Beever, P.R. Johnston, E.P. Laracy (PDD 55303). **Nelson**: Tākaka Saddle, on *Phormium tenax* living leaf, 17 Nov 1970, coll. J.M. Dingley (PDD 60647). **Northland**: Maunganui Bluff Scenic Reserve, on *Phormium tenax* living leaf, 19 Oct 1987, coll. E.H.C. McKenzie, P.R. Johnston (PDD 48400); Whangaruru North Head, on *Phormium tenax* living leaf, 28 Jan 1988, coll. P.R. Johnston (PDD 54127); Waipoua Forest, Lookout Track, on *Phormium tenax* living leaf, 11 May 2017, coll. P.R. Johnston D2429 (PDD 108765); Three Kings Islands, Great Island, vic. light beacon, on *Phormium tenax* living leaf, 27 Nov 1997, coll. R.E. Beever REB 1565-2 (PDD 68427).

Notes: First collected in the 1950s, this fungus is common on living leaves of *Phormium tenax* in north New Zealand. Although its host occurs throughout New Zealand, no specimens have been yet been collected south of Nelson or the Chatham Islands.

Marthamyces maccormackii P.R. Johnst., **sp. nov.** FIG. 7

IF 556324

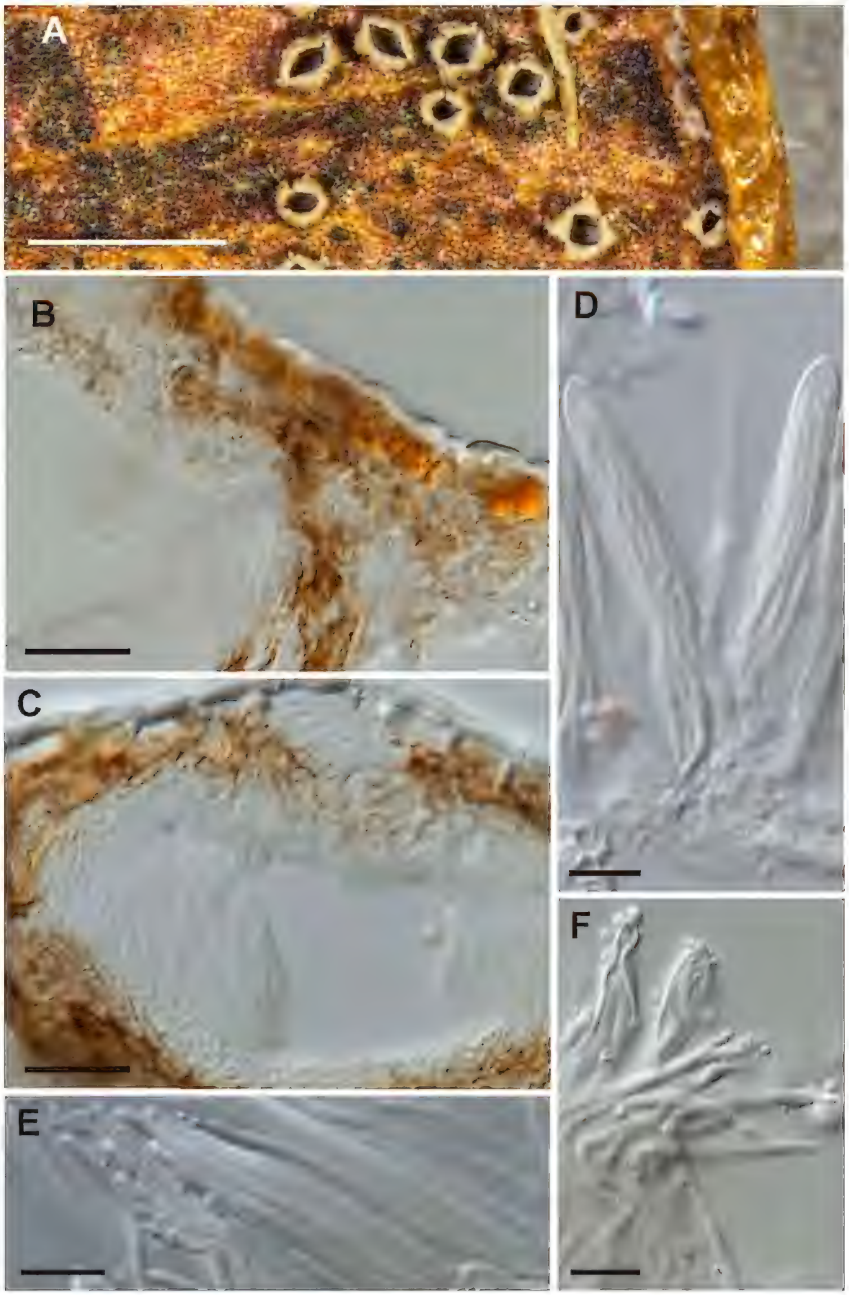
Differs from *M. emarginatus* by its darker ascomatal wall and from *M. metrosideri* by its rostrate ascus apex.

TYPE: Cook Islands: Rarotonga: Te Rua Manga, near summit, on *Metrosideros collina* fallen leaves, 28 Jun 2005, coll. P.R. Johnston RR392 (**holotype** PDD 112256; **ex-type culture** ICMP 15829).

ETYMOLOGY: Named in honour of Gerald McCormack, director of the Cook Islands Biodiversity and Natural Heritage Trust, who provided the support needed to collect the Cook Islands specimens cited here.

Ascomata developing on recently fallen leaves, often associated with slightly paler areas on the leaf, initially appearing as a slightly raised dark spot, opening initially as a pore, then by three to four radiate slits, the covering host and fungal tissue folding back as small triangular flaps, the undersides of which are covered with a layer of white crystals, exposed hymenial surface with a layer of whitish crystals. Mature ascomata 0.3–0.5 mm diam., more or less circular in shape, covering tissue normally darkened, pale in some collections, hymenial surface remaining well below the surface of the host tissue. Ascomata subepidermal, immature ascomata in vertical section with a 50 µm thick covering layer comprising partially decomposed host epidermal cells and several layers of fungal tissue. The outermost, clypeus-like layer comprises 3–4 rows of tangled hyphae 2.5–3.5 µm diam., with hyphal walls dark brown, irregularly thickened, but this is lacking near the centre of the ascoma. The upper wall of the ascoma comprises several layers of globose to angular cells 3–5 µm diam. with walls thin, slightly pigmented, and this layer of cells is lined with a layer of downward-projecting periphysoids 2–3 µm diam., with walls thin, hyaline. In mature ascomata the upper wall develops clumps of crystals forming amongst the globose to angular cells. Lower wall of the ascoma 15–20 µm thick, comprising several layers of tangled hyphae 2.5–3.5 µm diam. with hyphal walls dark brown, irregularly thickened. Paraphyses 2 µm diam., with several short, tapering branches near apex 1–1.5 µm diam., paraphyses about the same length as the asci. Asci 75–95 × 7.5–9 µm, cylindric, tapering suddenly to small, rostrate apex, wall undifferentiated, 8-spored. Ascospores 50–70 × 1.5–2 µm, gelatinous caps at each end small, flattened, 1-septate, hyaline.

ADDITIONAL SPECIMENS EXAMINED: **COOK ISLANDS**: **RAROTONGA**: Cross Island walk, near Te Rua Manga, on *Metrosideros collina*, 30 Jun 2005, coll. P.R. Johnston RR611 (PDD 112250, culture ICMP 16155); track to Ikurangi, near the top, on *M. collina* fallen leaves, 16 Jan 2005, coll. P.R. Johnston RR315 (PDD 112258, culture ICMP 15831); track to Ikurangi, near the top, on *M. collina* fallen leaves, 4 Jul 2005, coll. P.R. Johnston RR635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(PDD 112260); Te Rua Manga, near summit, on *M. collina* fallen leaves, 5 Jul 2005, coll. P.R. Johnston RR650 (PDD 112255).

Notes—There are two *Metrosideros*-inhabiting species of *Marthamyces* in the Cook Islands. *Marthamyces maccormackii* has small, circular ascomata with a dark upper wall, macroscopically remarkably similar to *M. metrosideri* from New Zealand but phylogenetically quite distinct and also different in having a rostrate rather than rounded ascus apex. A second, sympatric *Marthamyces* species from the same host in the Cook Islands has larger, more angular, less deeply immersed, paler-walled ascomata with a yellow hymenial surface and is described below as *M. renga*. Microscopically the two Cook Island species differ in ascus shape. The two species often form in lesions adjacent to each other on the same leaves.

Marthamyces metrosideri P.R. Johnst., **sp. nov.** Fig. 8

IF 556325

Differs from *Marthamyces emarginatus* by its *Metrosideros* host preference, its darker upper wall of ascomata, and its ascus tapering gradually to rounded apex.

Type: New Zealand: Wellington: Wainuiomata Waterworks Catchment Area, on *Metrosideros robusta* fallen leaves, 19 Nov 1992, coll. P.R. Johnston R965 (**holotype** PDD 67458; **ex-type culture** ICMP 22625).

Etymology: based on host genus name.

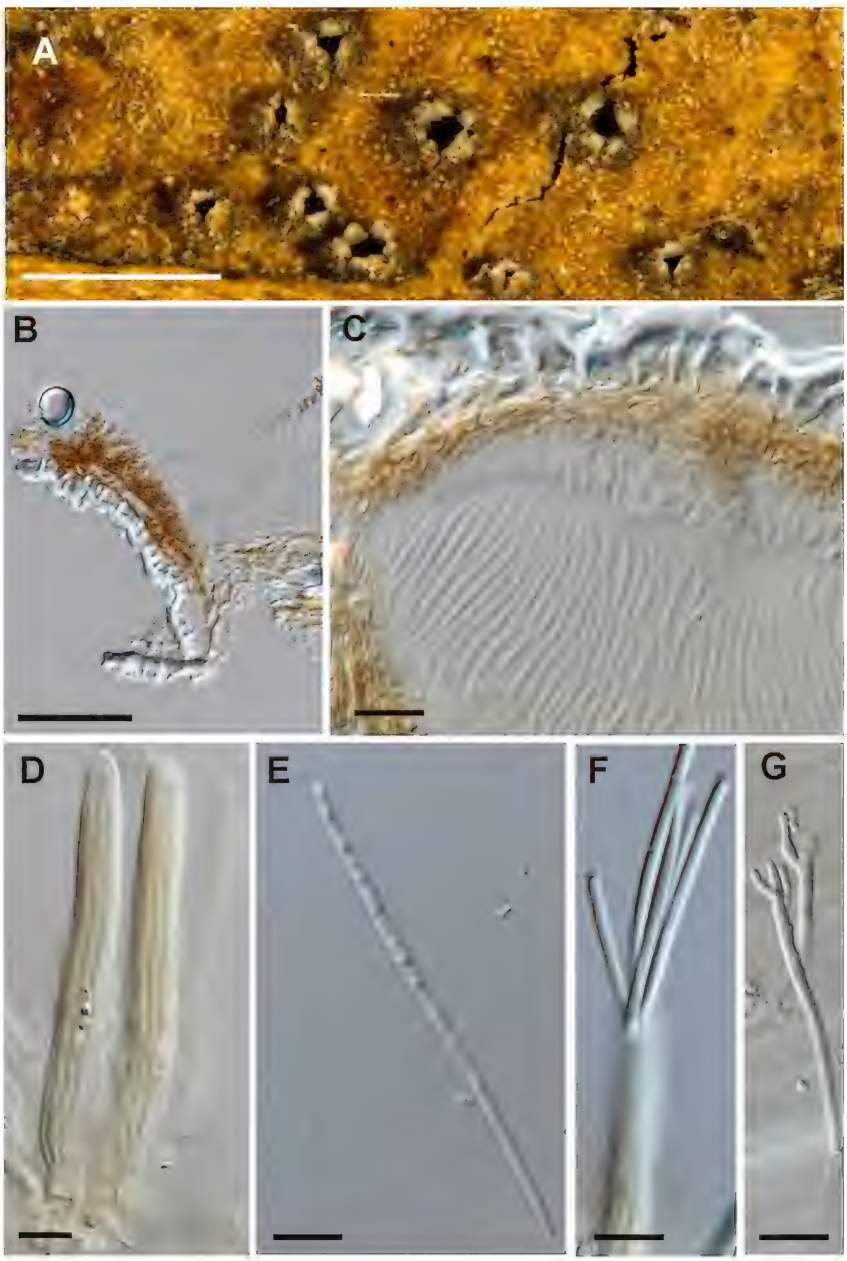
Ascomata developing within slightly paler areas on the lower surface of fallen leaves. Immature ascomata initially with appearance of small, darkened pustules. Mature ascomata round in outline, 0.3–0.4 mm diam., opening by several radiates slits, covering layer of host and fungal tissue folding back as 3–4 flaps lined with white crystals, exposing the white, pruinose hymenial surface. Ascomata subepidermal, in vertical upper wall of immature ascoma comprising 4–5 layers of angular to globose cells 3–5 µm diam., with walls thin, darkened, lined with layer of downward-projecting periphysoids, 15–30 × 3–3.5 µm, cylindric, unbranched, walls thin, hyaline. Lower wall of immature ascoma 20–35 µm thick, of several layers of hyphae 1.5–2.5 µm diam., with walls brown, slightly thickened, forming a loose textura intricata. Mature ascomata in vertical section with upper wall 70–100 µm thick, comprising a 10–30 µm wide layer of 3–5 µm diam. hyphae with cell walls thin, dark brown,

Figure 7. *Marthamyces maccormackii* (PDD 112256). A. Macroscopic appearance when dry; B. mature, opened ascoma in vertical section; C. Immature, unopened ascoma in vertical section; D. Asci; E. Flattened gel caps at top of ascospores; F. Paraphyses . Scale bars: A = 1 mm; B, C = 20 µm; D–F = 10 µm.

and a broad layer of crystals. Upper wall of mature ascomata lined with a layer of inward-projecting, hyaline, thin-walled periphysoids, individual elements shorter than in unopened ascomata, up to 10 µm long. Paraphyses 2–3 µm diam., with short side-branches 1–1.5 µm diam. near apex. Asci 70–105(–120) × 7–9.5 µm, subcylindric to subfusoid, tapering gradually to rounded to broadly rounded apex, wall undifferentiated at apex, 8-spored. Ascospores 45–85 × 2–3 µm, filiform, straight when released, tapering slightly and gradually towards the base, with small, flattened gelatinous caps at apex and base, 0–1-septate, hyaline.

Additional specimens examined: **NEW ZEALAND**: **Kermadec Islands**: Raoul Island, Denham Bay Track, on *Metrosideros kermadecensis*, 22 Sep 1988, coll. E.H.C. McKenzie (PDD 54664); Raoul Island, Blue Lake Track, on *M. kermadecensis*, 23 Sep 1988, coll. E.H.C. McKenzie (PDD 54666). **Northland**: Waipoua State Forest, Yakas Track, on *M. robusta*, 20 Oct 1987, coll. P.R. Johnston (PDD 48163); vic. Ōpononi, Waimamaku River mouth, on *M. excelsa*, 21 Oct 1987, coll. P.R. Johnston (PDD 53849); Whangaruru North Head, on *M. excelsa*, 28 Jan 1988, coll. P.R. Johnston (PDD 54117); Ahipara, Shipwreck Bay, on *M. excelsa*, 8 May 2017, coll. P.R. Johnston D2421 (PDD 111232). **Auckland**: Waitakere Ranges, Walker Bush, on *M. robusta*, 4 Aug 1982, coll. E.H.C. McKenzie, G.J. Samuels, P.R. Johnston R64 (PDD 43951); Huia Dam footbridge, on *M. excelsa*, 27 Apr 1982, coll. P.R. Johnston R52 (PDD 43952); Kaitarakihi Beach, on *M. excelsa*, 8 Mar 1983, coll. P.R. Johnston (PDD 43953); Piha Valley, Cowan Track, on *M. robusta*, 27 Apr 1983, coll. P.R. Johnston R209, G.J. Samuels, R.H. Petersen (PDD 43954); Mt Albert Research Centre, on *Metrosideros* sp., May 1983, coll. P.R. Johnston (PDD 43955); Kaitarakihi Beach, on *M. excelsa*, 20 Jul 1983, coll. P.R. Johnston (PDD 43958); Cornwallis Beach, on *M. excelsa*, 13 Apr 1984, coll. P.R. Johnston (PDD 49151). **Coromandel**: vic. Coromandel, 309 Road, Waiau Falls Scenic Reserve, on *M. robusta*, 25 Apr 1989, coll. P.R. Johnston (PDD 55341); Thames Coast, between Te Mata and Waikawau, on *M. excelsa*, 26 Aug 1999, coll. P.R. Johnston R1003, B.M. Spooner (PDD 70890); Tapu-Coroglen Road, 2 km Tapu side of summit, on *M. robusta*, 29 Aug 1984, coll. P.R. Johnston R552 (PDD 46194); North of Colville, vic. Ohinewai Stream, on *M. excelsa*, 27 Jan 1985, coll. P.R. Johnston (PDD 46775); Waihi, track N of beach, on *M. excelsa*, 9 May 2003, coll. P.R. Johnston (PDD 78201); Port Charles, between wharf and Big Sandy Bay, on *M. excelsa*, 26 Mar 1989, coll. P.R. Johnston (PDD 55293); Awaroa Stream, on *M. fulgens*, 12 Jun 1984, coll. P.R. Johnston (PDD 55294); Little Barrier Island, Titoki Point, on *M. excelsa*, 11 Jun 1984, coll. P.R. Johnston (PDD 45364); Little Barrier Island, near hut, on *M. excelsa*, 8 Apr 1988, coll. P.R. Johnston R795 (PDD 48768); Little Barrier Island, south of Te Wairere, on *M. excelsa*, 9 Mar 1974, coll. W.B. Kendrick (PDD 40728). **Gisborne**: Urewera National Park, Ngāmoko

Figure 8. *Marthamyces metrosideri* (A–C, E–G. PDD 111232; D. PDD 55341). A. Macroscopic appearance when dry; B. Mature, opened ascoma in vertical section; C. Immature, unopened ascoma in vertical section; D. Asci; E. Released ascospore; F. Apex of ascospores showing gel caps; G. Paraphyses. Scale bars: A = 1 mm; B, C = 20 µm; D–G = 10 µm.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Track, on *M. robusta*, 10 May 2001, coll. P.R. Johnston (PDD 74308); vic. Ruatāhuna, Mangapae, on *M. robusta*, 24 May 2005, coll. P.R. Johnston R1033, T. Hosoya (PDD 82920). **Taranaki**: Mt Egmont, Waiweranui Track, on *M. robusta*, 25 Apr 1983, coll. P.R. Johnston R274, G.J. Samuels, R.H. Petersen (PDD 43957). **Wanganui**: Kai Iwi, Bushy Park Reserve, on *M. robusta*, 15 May 1987, coll. P.R. Johnston (PDD 45587). **Nelson**: Karamea Bluff, Large Matai Track, on *M. robusta*, 25 May 1989, coll. P.R. Johnston, E.M. Gibellini (PDD 57159); Karamea, 1 km S Granite Creek Road, on *M. robusta*, 14 Apr 1983, coll. P.R. Johnston R262, G.J. Samuels, R.E. Beever (PDD 43956, culture ICMP 22624). **Buller**: vic. Greymouth, Point Elizabeth Walkway, on *M. robusta*, 1 May 1985, coll. P.R. Johnston R645, G.J. Samuels, L.M. Kohn (PDD 46961). **Westland**: Haast, Hāpuku River mouth, on *M. umbellata*, 11 May 2002, coll. S.R. Whitton, T. Atkinson (PDD 75509).

Notes—This common, *Metrosideros*-inhabiting fungus was previously identified as *M. emarginatus* (Johnston 1986, as *Propolis emarginata;* McKenzie & al. 1999, as *Propolis emarginata*). Based on published descriptions (e.g. Sherwood 1977), examination of the type specimen of *M. emarginatus*, and the features of the specimens from *Eucalyptus* from Australia deposited as PDD 81844, PDD 81845, and PDD 81846, the two species are very similar but slight, apparently consistent morphological differences (see diagnosis) are matched by the five transitions across the ITS1 and ITS2 regions.

Marthamyces renga P.R. Johnst., **sp. nov.** Fig. 9

IF 556326

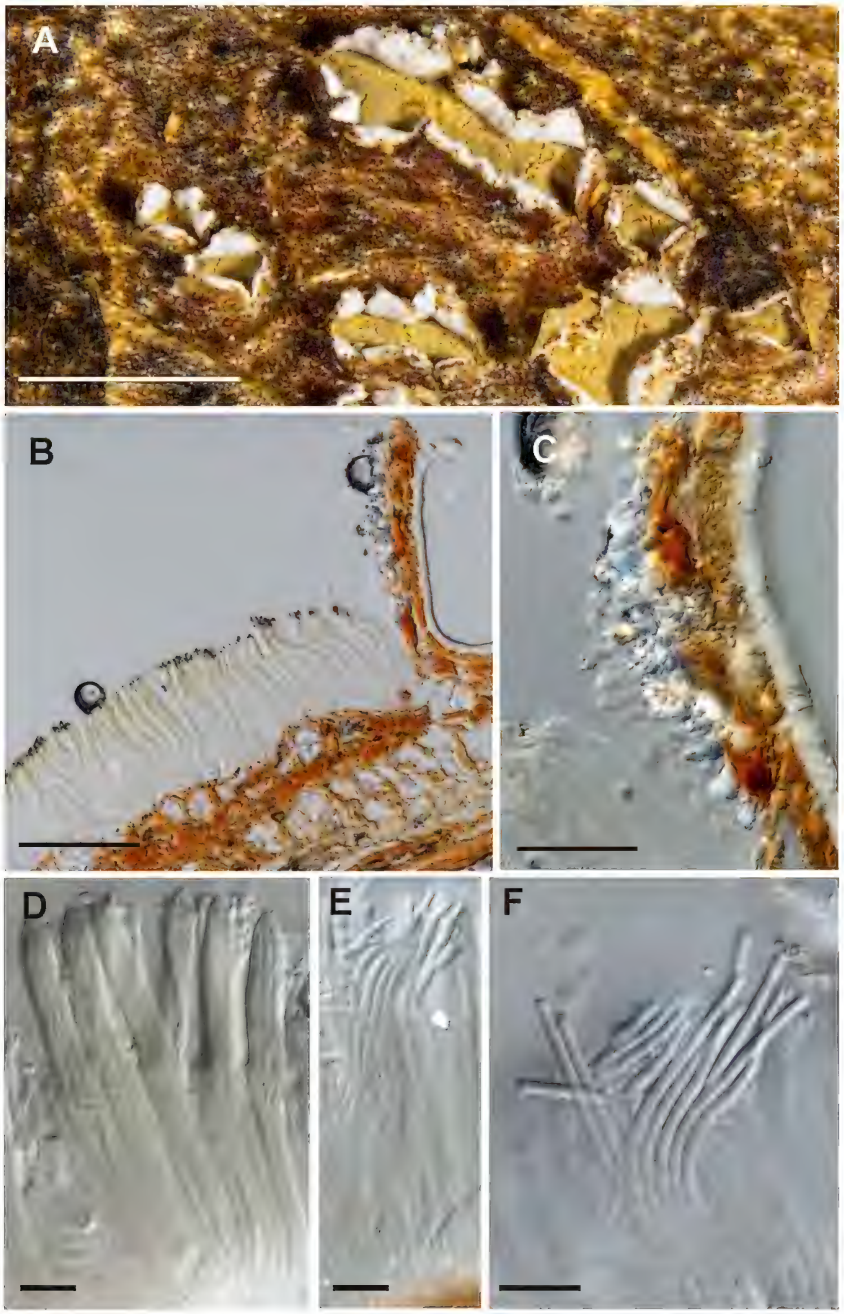
Differs from *Marthamyces emarginatus* by its larger, more angular, less deeply immersed ascomata, and its sharp contrast between the white crystals lining the upper wall and the yellow crystals on the hymenial surface.

Type: Cook Islands: Rarotonga: Raemaru Track, summit, on *Metrosideros collina* fallen leaves, 28 Jun 2005, coll. P.R. Johnston RR562 (**holotype** PDD 112263).

Etymology: renga, Cook Island Māori word for yellow, referring to the colour of the hymenial surface.

Ascomata developing within slightly paler areas on both the upper and lower surface of recently fallen leaves, initially appear as slightly raised patches, these splitting open by 3–4(–5) radiate slits, the covering host and fungal tissue folding back as small flaps, the undersides of which are covered with a layer of white crystals, the exposed hymenial surface crystalline, yellow. Mature ascomata 0.4–1.5 × 0.4–0.8 mm, angular, 3–5-sided. Ascomata subepidermal, in vertical section mature ascomata with a covering layer 50–60 µm thick,

Figure 9. *Marthamyces renga* (A–C. PDD 112263; D–F. PDD 112259). A. Macroscopic appearance when dry; B. Mature, opened ascoma in vertical section; C. Detail of upper wall of opened ascoma in vertical section; D. Asci; E. Paraphyses; F. Apex of ascospores with flattened gel cap. Scale bars: A = 1 mm; B = 100 µm; C–F = 10 µm.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comprising mostly partially broken-down cells of the host leaf tissue, together with crystals forming within a thin layer of more-or-less globose fungal cells with walls thin, hyaline, lined with a layer of broad-cylindric periphysoids, 10–20 × 4–6 µm, thin-walled, hyaline, unbranched. Lower wall 10–15 µm thick, comprising a compact layer of 3–4 µm diam. hyphae with cell walls hyaline, slightly thickened. Paraphyses 2–2.5 µm diam., with several short, tapering branches near apex 1–1.5 µm diam., intermixed with groups of small crystals, paraphyses about the same length as the asci. Asci 75–90 × 7–9.5 µm, cylindric, tapering slightly to rounded apex, wall undifferentiated, 8-spored. Ascospores rarely seen released, 1.5–2 µm wide, about 55–70 µm long, gelatinous caps at each end small, flattened, 1-septate, hyaline.

Additional specimens examined: **COOK ISLANDS**: **Rarotonga**: Te Rua Manga, on track near summit, on *Metrosideros collina* fallen leaves, 21 Jan 2005, coll. P.R. Johnston RR393 (PDD 112257; culture ICMP 15830); Te Kou, on track near summit, on *Metrosideros collina* fallen leaves, 19 Jan 2005, coll. P.R. Johnston RR380 (PDD 112259; culture ICMP 15827). Te Rua Manga, on track near summit, on *Vaccinium cereum* fallen leaves, 5 Jul 2005, coll. P.R. Johnston RR397 (PDD 112261). Te Rua Manga, on track near summit, *Vaccinium cereum* fallen leaves, 5 Jul 2005, coll. P.R. Johnston RR642 (PDD 112264). Te Rua Manga, on track near summit, on *Weinmannia samoensis* fallen leaves, 5 Jul 2005, coll. P.R. Johnston RR641 (PDD 112262).

Notes: A macroscopically distinctive species with a marked contrast in colours between the white crystals on the underside of the upper wall of the ascoma and the yellow crystals on the hymenial surface. Although common on *Metrosideros collina*, this species is not host-specialized and was found also on recently fallen leaves of *Vaccinium cereum* G. Forst. (*Ericaceae*) and *Weinmannia samoensis* A. Gray (*Cunoniaceae*), both south Polynesian endemic plant species found in Rarotonga in the same high-altitude plant communities as *Metrosideros*. See also notes under *M. maccormackii*.

Ramomarthamyces P.R. Johnst., **gen. nov.**

IF 556327

Differs from *Marthamyces* by its distinctly branched paraphyses.

Type species: *Propolis dracophylli* P.R. Johnst. [= *Ramomarthamyces dracophylli* (P.R. Johnst.) P.R. Johnst.]

Etymology: *ramo* = branch; refers to the branched paraphyses in these *Marthamyces*-like fungi.

Ascomata immersed in the host tissue, opening by several radiate slits to reveal the pruinose, crystalline hymenial surface. Ascus wall undifferentiated at the apex, ascospores filiform, paraphyses branched several times near the apex.

NOTES: A genus in the *Marthamycetaceae*, but molecular phylogenetic analysis shows it to be phylogenetically distinct from other genera within the family (FIG. 1). The genetic difference is supported by a characteristic morphology, all species known for the genus having distinctly branched, rather than propoloid, paraphyses. *Marthamyces* is macro-morphologically similar.

Ramomarthamyces tuku P.R. Johnst., **sp. nov.** FIG. 10

IF 556333

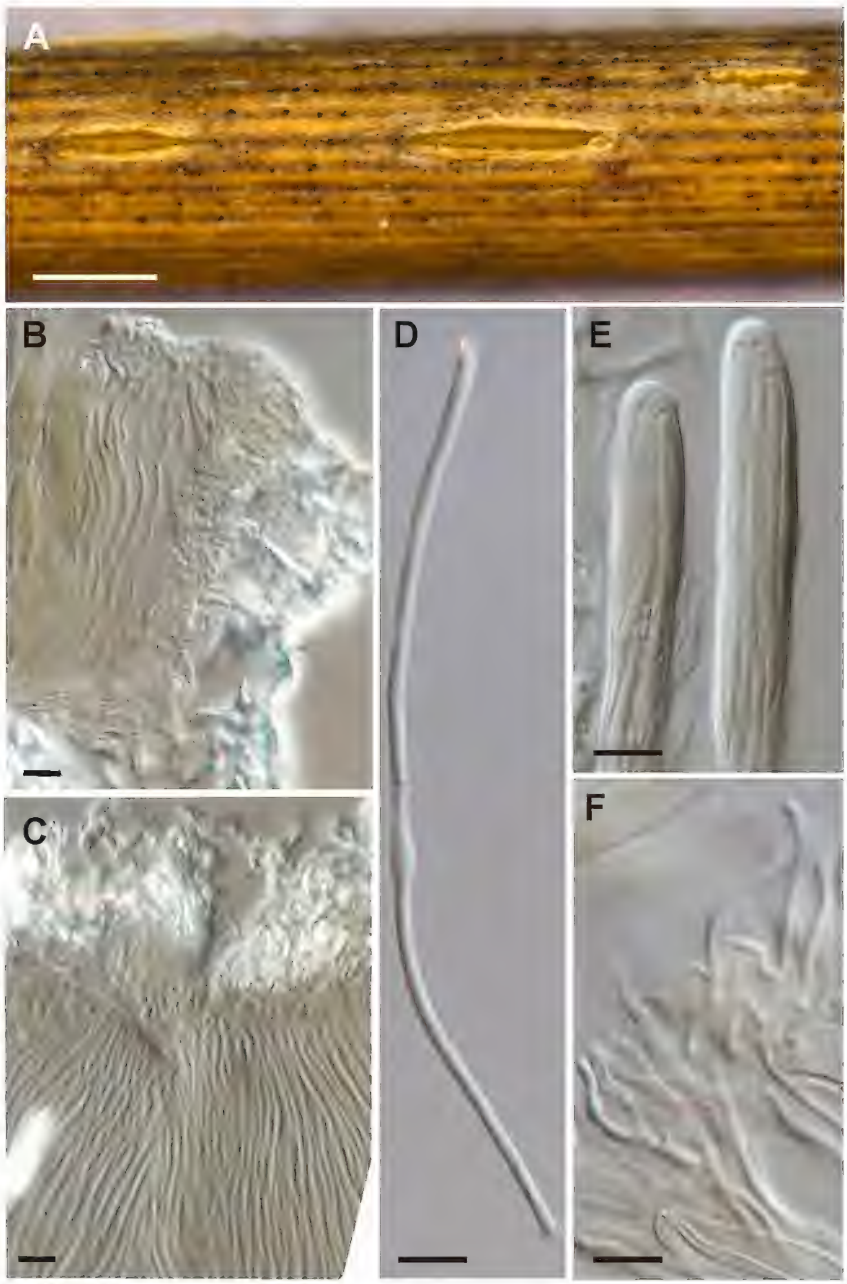
Differs from *Ramomarthamyces gilvus* by its *Juncaceae* host, its elongate ascoma, its ascospores with a swelling above the septum, its undifferentiated ascus wall, and its lack a well-developed layer of crystals amongst the paraphyses.

TYPE: New Zealand, Chatham Islands, Rekohu, Tuku Reserve, on *Juncus* sp., dead leaves, 19 Nov 1992, coll. P.R. Johnston C42, R911 & E.H.C. Mckenzie (**holotype** PDD 62161; **ex-type culture** ICMP 22562).

ETYMOLOGY: tuku, based on type locality.

Ascomata developing on dead leaves, not associated with discoloured areas. Ascomata 0.5–1 × 0.2–0.3 mm, immersed in the leaf, opening by an elongate slit, covering layer slightly paler than the surrounding leaf tissue, sometimes with poorly developed crystalline layer near edge of opening slit, exposed hymenium translucent yellow, lacking obvious crystals. Ascomata intrahypodermal, in vertical section immature ascomata with a covering layer 50–70 µm thick, comprising most partly decomposed host cells intermixed with a poorly developed, clypeus-like layer of hyphae 3–5 µm diam. with walls thin, hyaline. Beneath the host cells is a 10 µm thick layer of narrow tangled hyphae with walls thin, hyaline, this layer lined with broad-cylindric periphysoids 10–15 × 4–5 µm, with walls thin, hyaline. Mature ascomata similar in vertical section but periphysoids more or less lost, and clumps of crystals forming amongst the hyphae of the upper wall near the opening slit. Lower wall 10–15 µm thick, comprising several rows of narrow, tangled hyphae with walls thin, hyaline. Paraphyses 1.5–2 µm diam., several times branched near the apex, extending 20–25 µm beyond asci. Asci 115–125 × 9–10 µm, cylindric, apex broadly rounded, wall undifferentiated at apex, 8-spored. Ascospores 110 × 2–3 µm, 1-septate, a small swelling 3.5–4 µm diam. immediately above the septum, otherwise not tapering, more or less globose gelatinous caps at each end, 3–3.5 µm diam.

NOTES: Although known only from the type specimen, this is a clearly distinct species, both morphologically and phylogenetically. An inconspicuous fungus, it is likely to be widespread on *Juncus* in New Zealand. The closely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related *R. gilvus* is known from several cyperaceous hosts in Australia and it is possible that with more collections, *R. tuku* will be found to have a broader range of hosts. The New Zealand species *Marthamyces dendrobii* has similar distinctively shaped ascospores, with a small swelling immediately above the central septum, but differs in host, its ascoma having a dark upper wall, and its smaller ascospores.

Ramomarthamyces barbatus (P.R. Johnst.) P.R. Johnst., **comb. nov.**

IF 556329

≡ *Marthamyces barbatus* P.R. Johnst., Aust, Syst, Bot, 19: 137, 2006.

NOTE: Recombination based on both DNA sequence and morphological data.

Ramomarthamyces dracophylli (P.R. Johnst.) P.R. Johnst., **comb. nov.**

IF 556330

≡ *Propolis dracophylli* P.R. Johnst., New Zealand J. Bot. 24: 115, 1986.

≡*Marthamyces dracophylli* (P.R. Johnst.) Minter, Mycotaxon 87: 51, 2003.

NOTE: Recombination based on both DNA sequence and morphological data.

Ramomarthamyces gilvus (Rodway) P.R. Johnst., **comb. nov.**

IF 556331

≡ *Naemacyclus gilvus* Rodway, Pap. & Proc. Roy. Soc. Tasmania 1917: 107, 1918.

≡ *Marthamyces gilvus* (Rodway) P.R. Johnst., Aust. Syst. Bot. 19: 140, 2006.

NOTE: Recombination based on both DNA sequence and morphological data.

Discussion

Marthamyces harakeke is widespread and common as a leaf spot on *Phormium* in New Zealand. The earliest fungarium specimen of the fungus was collected in 1956 and deposited in PDD as *Propolis* sp., but with a note that the identification was uncertain. Later specimens were also referred to *Propolis* by several different mycologists. Although macroscopically the fungus is *Propolis*-like in having apothecia shallowly immersed in host tissue, a crystalline hymenial surface, and asci undifferentiated at the apex, there was always doubt about its identity because of the pathogenic lifestyle. It was not until DNA sequences were obtained from a specimen collected in 2017

FIGURE 10. *Ramomarthamyces tuku* (PDD 62161). A. Macroscopic appearance when dry; B. Mature, opened ascoma in vertical section; C. Immature, unopened ascoma in vertical section, showing periphysoids; D. Ascospore with a globose gel cap at each end; E. Apex of asci; F. Apex of paraphyses. Scale bars: A = 1 mm; B, C = 20 μm; D–F = 10 μm.

that its generic position was resolved. Today the genus used for this fungus and its relatives is *Marthamyces,* a generic name now used for several species that had been placed in *Propolis* in the past.

Both *Propolis* and *Marthamyces* were placed in *Rhytismataceae* at the time that Lantz & al. (2011) published a molecular phylogeny treating the *Rhytismatales* in depth. Their results showed the *Rhytismataceae* to be polyphyletic, and they regarded *Propolis* and *Marthamyces* as incertae sedis within the *Leotiomycetes*. With support from rDNA-based phylogenies, Baral (2015) placed *Propolis* and *Marthamyces* along with several other genera in a separate family, *Marthamycetaceae*, and more recently Johnston & al. (2019) erected the order *Marthamycetales*, based on a 15-loci analysis. In the present paper, species placed in the genus *Marthamyces* have been more intensively sampled with molecular data, and the genus was shown to be polyphyletic. As a result we created the genus *Ramomarthamyces* for species segregated from *Marthamyces* sensu stricto.

The phylogeny presented here shows a pathogenic lifestyle to have evolved more than once in the *Marthamycetaceae*. Along with *M. harakeke*, *M. culmigenus* (in a clade of species separate from that containing *M. harakeke*) and the *Cyclaneusma* species cause foliar diseases.

Marthamyces emarginatus was originally described from *Eucalyptus* from Victoria, Australia. *Marthamyces emarginatus*-like fungi are common on recently fallen *Eucalyptus* leaves in Australia, but the data presented here show that several closely related but phylogenetically distinct species occur on this substrate. Insufficient samples are available to determine whether there is a relationship between this diversity with respect to geography, or to phylogeny within *Eucalyptus*. Until the distribution of these fungi in Australian forests is better understood, a neotype cannot be selected for *M. emarginatus*.

Two GenBank accessions identified as *Coccomyces proteae* have ITS sequences that closely match *Marthamyces emarginatus*-like species (CBS 111703 as JN712451; CBS 111704 as JN712450; Fig. 2). Based on (Marincowitz & al. 2008) the morphology of *C. proteae* is typical of *Coccomyces*. It is possible that the putative *C. proteae* cultures from which these sequences were derived represent another, possibly undescribed, species of *Marthamyces* that grows on *Protea* leaves in South Africa. Note that another GenBank accession identified as *Coccomyces proteae* (JX089385 ex leaves of *Disterigma humboldtii* (*Ericaceae*) ex Puerto Rico) represents yet another *Marthamyces* species, this one belonging in the clade containing *M. maccormackii, M. renga,* and *M. culmigenus* (Fig. 2).

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Septobasidium aquilariae sp. nov. from Yunnan, China

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Abstract—A new fungal species, *Septobasidium aquilariae*, is proposed based on a combination of morphological features and molecular evidence. The species is characterized by an annual growth habit; a resupinate coriaceous basidiocarp with a cream to pale brown surface; a monomitic hyphal system with thick-walled generative hyphae bearing simple septa; reniform, hyaline, thin-walled, smooth basidiospores measuring 11–19 × 4–7.5 µm; and haustoria consisting of irregularly coiled hyphae. The fungus was found associated with *Pseudaulacaspis* sp. on *Aquilaria sinensis*. Sequences of internal transcribed spacer region (ITS) were analysed maximum likelihood, maximum parsimony, and Bayesian inference methods. The phylogenies strongly supported *S. aquilariae* in a monophyletic lineage (ML = 100%; MP = 100%; PP = 1) and grouped with "*S. cokeri*".

Key words—felt fungus, *Pucciniomycetes*, *Septobasidiaceae*, *Septobasidiales*, taxonomy

Introduction

Septobasidium Pat. (*Septobasidiaceae, Septobasidiales*), erected by Patouillard (1892), is a large, cosmopolitan genus characterized by resupinate basidiocarps with a white to cream, yellowish brown or brown hymenophore, a monomitic hyphal system with simple septa, with or without probasidia, 2–4 celled cylindrical, curved, or straight basidia, basidiospores that are hyaline, thin-walled, smooth, and cylindrical or fusiform, and haustoria consisting

of coiled or spindle-shaped hyphae (Patouillard 1892, Couch 1929). About 300 species have been accepted in the genus worldwide (Patouillard 1892; Bresadola & Saccardo 1897; Burt 1916; Lloyd 1919; Couch 1929, 1935, 1938, 1946; Yamamoto 1956; Gómez & Henk 2004; Henk 2005; Lu & Guo 2009a,b, 2010a,b, 2011; Lu & al. 2010; Chen & Guo 2011, 2012; Li & Guo 2013, 2014).

Molecular systematics have played a powerful role in inferring phylogenies within fungal groups since the early 1990s (White & al. 1990, Binder & al. 2013, Dai & al. 2015, Choi & Kim 2017). However, molecular studies involving *Septobasidium* are rare (Henk & Vilgalys 2007, Zhao & al. 2017). One phylogenetic study of a single origin of insect symbiosis in the *Pucciniomycetes* suggested that there is little or no support for *Septobasidium* as a monophyletic group (Henk & Vilgalys 2007). Zhao & al. (2017) introduced a six-gene phylogenetic overview of *Basidiomycota* and allied phyla and confirmed that *S. carestianum* Bres. nested within the *Septobasidiales* and grouped with *Helicobasidium mompa* Nobuj. Tanaka and *Thanatophytum crocorum* (Pers.) Nees.

During disease investigations on *Aquilaria sinensis* in southern China, a new *Septobasidium* taxon was found that could not be assigned to any described species. In this study, we expand samplings from previous studies to examine the taxonomy and ITS phylogeny of this new species within the *Septobasidium*.

Materials & methods

The specimens studied are deposited at the herbarium of Southwest Forestry University, Kunming, China (SWFC). Macromorphological descriptions are based on field notes. Colour terms follow Petersen (1996). Micromorphological data were obtained from dried specimens observed under a light microscope. Measurements are presented as: L = mean spore length, W = mean spore width, Q = range of L/W ratios, n = number of spores/number of specimens.

Genomic DNA was obtained from dried specimens using the EZNA HP Fungal DNA Kit, according to the manufacturer's instructions with some modifications. A small piece of dried fungal specimen (about 30 mg) was ground to powder with liquid nitrogen. The powder was transferred to a 1.5 ml centrifuge tube, suspended in 0.4 ml of lysis buffer, and incubated in a 65 °C water bath for 60 min. After that, 0.4 ml phenol-chloroform (24:1) was added to each tube and the suspension was shaken vigorously. After centrifugation at 13,000 rpm for 5 min, 0.3 ml supernatant was transferred to a new tube and mixed with 0.45 ml binding buffer. The mixture was then transferred to an adsorbing column (AC) for centrifugation at 13,000 rpm for 0.5 min. Then, 0.5 ml inhibitor removal fluid was added in AC for a centrifugation at 12,000 rpm for 0.5 min. After washing twice with 0.5 ml washing buffer, the AC was transferred to a clean centrifuge tube,

Table 1. Species, specimens, and ITS sequences used in *Septobasidium* molecular analyses.

Species	Sample	GenBank ITS	Reference
Helicobasidium mompa	DAH h1	DQ241472	Henk & Vilgalys 2007
Pachnocybe ferruginea	DAH pf1	DQ241473	Henk & Vilgalys 2007
Septobasidium alni	DAH FP3	DQ241441	Henk & Vilgalys 2007
S. aquilariae	**CLZhao 6610**	MK802139	Present study
	CLZhao 6611 [T]	MK802140	Present study
	CLZhao 6612	MK802141	Present study
	CLZhao 6613	MK802142	Present study
	CLZhao 6614	MK802143	Present study
S. arachnoideum	DAH 025	DQ241443	Henk & Vilgalys 2007
S. bogoriense	998434	HM209414	Unpublished
S. broussonetiae	998436	HM209416	Unpublished
S. burtii	DAH 062	DQ241444	Henk & Vilgalys 2007
S. carestianum	DJM 644	DQ241448	Henk & Vilgalys 2007
S. castaneum	DAH 052	DQ241447	Henk & Vilgalys 2007
S. cavarae	DJM FP1	DQ241445	Henk & Vilgalys 2007
"S. cokeri"	DAH 061	DQ241449	Henk & Vilgalys 2007
S. fumigatum	DAH 005	DQ241451	Henk & Vilgalys 2007
S. gomezii	DAH 031	DQ241462	Henk & Vilgalys 2007
S. grandisporum	DAH 065	DQ241453	Henk & Vilgalys 2007
S. hainanense	998437	HM209417	Unpublished
S. kameii	998432	HM209412	Unpublished
S. maesae	998433	HM209413	Unpublished
S. marianiae	DAH 283b	DQ241456	Henk & Vilgalys 2007
S. michelianum	DAH FP5	DQ241457	Henk & Vilgalys 2007
S. pallidum	998435	HM209415	Unpublished
S. pilosum	DAH 020	DQ241458	Henk & Vilgalys 2007
S. pinicola	DAH 013	DQ241459	Henk & Vilgalys 2007
S. pseudopedicellatum	DAH 044	DQ241460	Henk & Vilgalys 2007
S. ramorum	DAH 045a	DQ241450	Henk & Vilgalys 2007
S. septobasidioides	DAH 032	DQ241461	Henk & Vilgalys 2007
S. taxodii	DAH 194C	DQ241466	Henk & Vilgalys 2007
S. velutinum	DAH 024	DQ241467	Henk & Vilgalys 2007
S. westonii	DAH FP2001	DQ241468	Henk & Vilgalys 2007
S. wilsonianum	DAH 037	DQ241469	Henk & Vilgalys 2007

and 100 ml elution buffer was added to the middle of adsorbed film to elute the genomic DNA. ITS region was amplified with primer pairs ITS5 and ITS4 (White & al. 1990). The PCR procedure was as follows: initial denaturation at 95 °C for 3 min; followed by 35 cycles of 94 °C for 40 s, 58 °C for 45 s, and 72 °C for 1 min; and a final extension of 72 °C for 10 min. The PCR products were purified and directly sequenced at Kunming Tsingke Biological Technology Limited Company. All newly generated sequences were deposited at GenBank (Table 1).

Sequencher 4.6 was used to edit the DNA sequence. Sequences were aligned in MAFFT 6 (Katoh & Toh 2008; http://mafft.cbrc.jp/alignment/server/) using the "G-INS-I" strategy and manually adjusted in BioEdit (Hall 1999). The sequence alignment was deposited in TreeBase (submission ID 23722). Sequences of *Helicobasidium mompa* and *Pachnocybe ferruginea* Berk. obtained from GenBank were used as outgroups to root trees following Henk & Vilgalys (2007) in the ITS analysis (Fig. 1).

Maximum parsimony analysis was applied to the ITS dataset sequences. Approaches to phylogenetic analysis followed Zhao & al. (2013) and Song & al. (2016), and the tree construction procedure was performed in PAUP* version 4.0b10 (Swofford 2002). All characters were equally weighted, and gaps were treated as missing data. Trees were inferred using the heuristic search option with TBR+G branch swapping and 1000 random sequence additions. Max-trees were set to 5000, branches of zero length were collapsed and all parsimonious trees were saved. Clade robustness was assessed using a bootstrap (BP) analysis with 1000 replicates (Felsenstein 1985). Descriptive tree statistics tree length (TL), consistency index (CI), retention index (RI), rescaled consistency index (RC), and homoplasy index (HI) were calculated for each Maximum Parsimonious Tree (MPT) generated. Sequences were also analyzed using Maximum Likelihood (ML) with RAxML-HPC2 on Abe through the Cipres Science Gateway (www.phylo.org; Miller & al. 2009). Branch support (BS) for ML analysis with GTR+G+I model of site substitution including estimation of Gamma-distributed rate heterogeneity and a proportion of invariant sites. The branch support was evaluated with bootstrapping method of 1000 replicates.

MrModeltest 2.3 (Posada & Crandall 1998; Nylander 2004) was used to determine the best-fit evolution model for each data set for Bayesian inference (BI). Bayesian inference was calculated with MrBayes3.1.2 with a general time reversible (GTR+G+I) model of DNA substitution and a gamma distribution rate variation across sites (Ronquist & Huelsenbeck 2003). Four Markov chains were run for 2 runs from random starting trees for 3 million generations (Fig. 1) and trees were sampled every 100 generations. The first one-fourth generations were discarded as burn-in. A majority rule consensus tree of all remaining trees was calculated. Branches were considered as significantly supported if they received maximum likelihood bootstrap (ML)>70%, maximum parsimony bootstrap (MP) >50%, or Bayesian posterior probabilities (PP) >0.95.

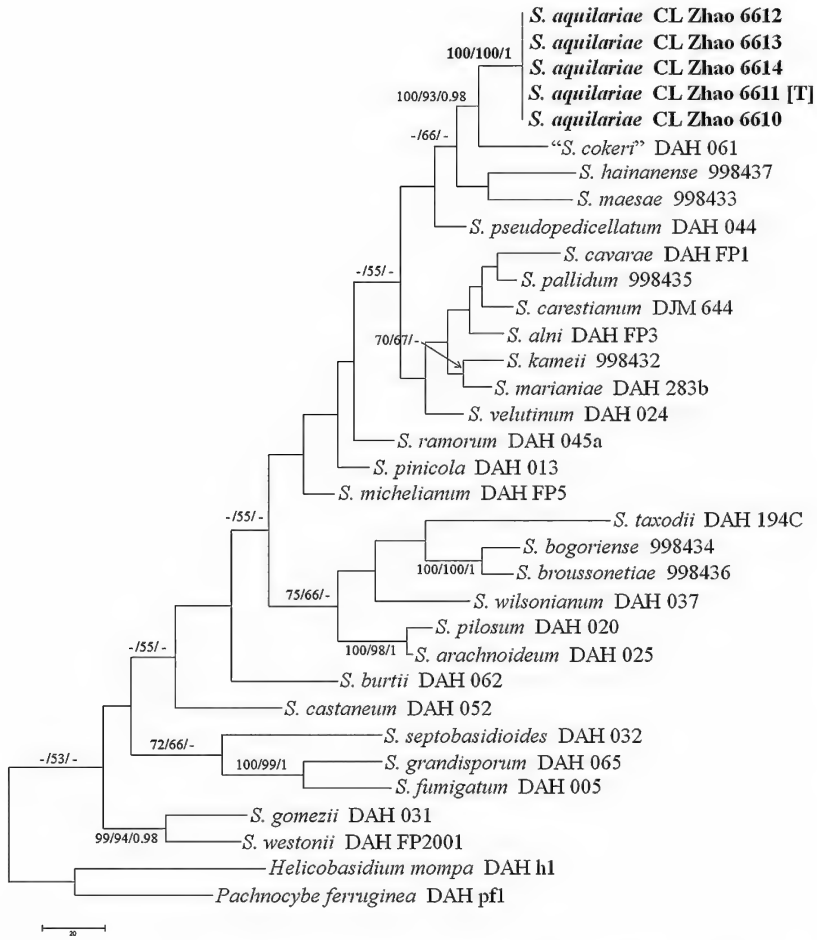


FIG. 1. Maximum Parsimony strict consensus tree illustrating the phylogeny of *Septobasidium aquilariae* and related species in *Septobasidium* based on ITS sequences, with *Helicobasidium mompa* and *Pachnocybe ferruginea* as outgroup. Branches are labeled with maximum likelihood bootstrap >70%, maximum parsimony bootstrap >50% and Bayesian posterior probabilities >0.95.

Phylogeny

The ITS dataset included sequences from 34 fungal specimens representing 29 species. The dataset had an aligned length of 617 characters, of which 315 are constant, 106 are variable and parsimony-uninformative, and 196 are parsimony-informative. Maximum parsimony analysis yielded 12

equally parsimonious trees (TL = 1143, CI = 0.434, HI = 0.566, RI = 0.454, RC = 0.197). Best model for the ITS dataset estimated and applied in the Bayesian analysis: GTR+I+G, lset nst = 6, rates = invgamma; prset statefreqpr = dirichlet (1,1,1,1). Bayesian analysis and ML analysis resulted in a similar topology as MP analysis, with an average standard deviation of split frequencies = 0.008724 (BI).

The Maximum Parsimony strict consensus tree (Fig. 1) inferred from ITS sequences within *Septobasidium* demonstrated that the new species formed a monophyletic lineage with strong support (ML = 100%; MP = 100%; PP = 1) and formed a sister clade with *"S. cokeri"* Couch [nom. inval.] and forming a group with *S. hainanense* C.X. Lu & L. Guo and *S. maesae* C.X. Lu & L. Guo.

Taxonomy

Septobasidium aquilariae C.L. Zhao, **sp. nov.** Figs 2, 3

MB 830332

Differs from "*Septobasidium cokeri*" by its slightly brown to brown hymenial surface upon drying and its growth on *Aquilaria sinensis*.

Type: China. Yunnan Province: Xishuangbanna, Jinghong, Menghai County, in association with *Pseudaulacaspis* sp. on *Aquilaria sinensis*, 31 May 2018, CLZhao 6611 (**Holotype**, SWFC 006611; MK802140).

Etymology: The specific epithet *aquilariae* (Lat.) refers to the plant genus on which all of the specimens were collected.

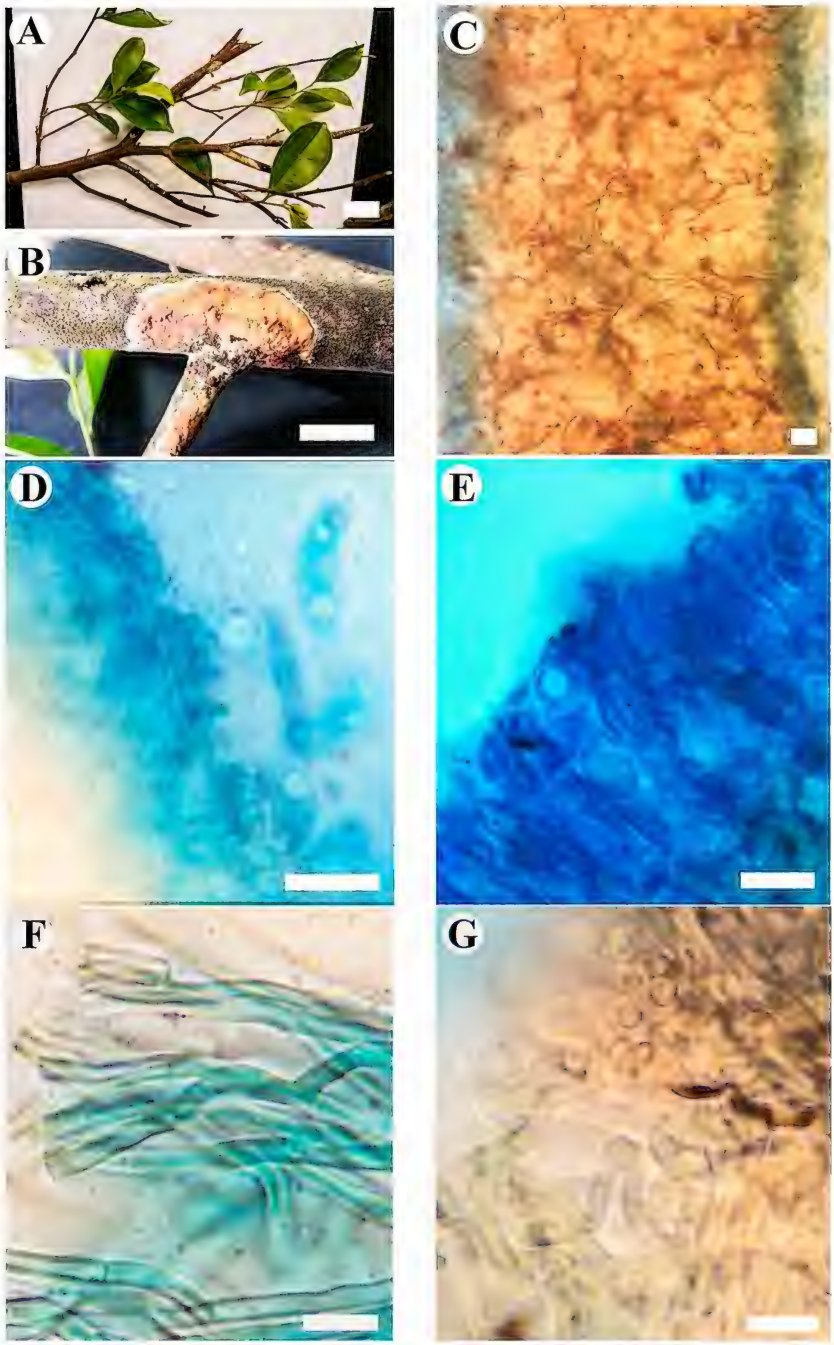
Basidiomata on branches, annual, resupinate, hard to separate from substrate, becoming coriaceous upon drying, up to 8 cm long, up to 4 cm wide, up to 1 mm thick. Hymenial surface smooth, cream to pale brown when fresh, slightly brown to brown upon drying. Sterile margin indeterminate, white to cream.

Hyphal structure monomitic; generative hyphae with simple septa, pale brown, thick-walled. In section 800–1000 μm thick; subiculum pale brown, 50–150 μm thick; pillars brown, 300–400 μm high, 50–100 μm wide; hyphal layer pale brown, 150–350 μm thick; hymenium hyaline or brown, 70–100 μm thick.

Basidia arising directly from the hyphae without a probasidial cell, cylindrical, curved, or straight, hyaline, 2–4-celled, 15–26.5 × 4–6 μm.

Basidiospores reniform, hyaline, thin-walled, smooth, (10–)11–19(–20.5) × (3.5–)4–7.5(–8) μm, L = 14.15 μm, W = 6.12 μm, Q = 1.81–2.52 (n = 150/5). Haustoria consisting of irregularly coiled hyphae.

Fig. 2. *Septobasidium aquilariae* (holotype, SWFC 006611). A, B. Basidiomata on branch; C. Sections of basidiomata; D. Basidiospore; E. Basidia; F. Hyphae; G. Haustoria. Scale bars: a = 5 cm; b = 2 cm; c–g = 10 μm.


A
B
C
D
E
F
G

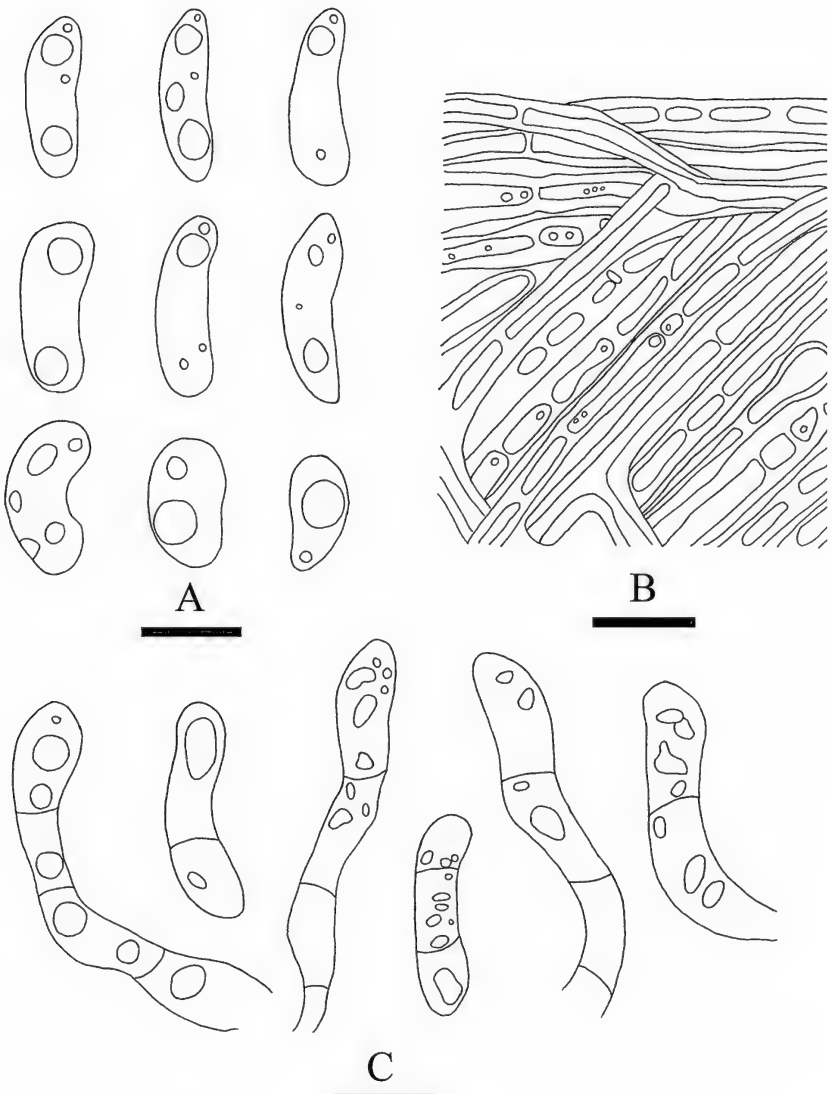


Fig. 3. *Septobasidium aquilariae* (holotype, SWFC 006611).
A. Basidiospores; B. Generative hyphae from hyphal layer; C. Basidia. Scale bars = 10 μm.

Habitat and distribution growing in association with *Pseudaulacaspis* sp. on *Aquilaria sinensis* (Lour.) Spreng. (*Thymelaeaceae*).

Additional specimens examined: **CHINA. Yunnan province. Xishuangbanna:** Jinghong, Menghai County, in association with *Pseudaulacaspis* sp. on *Aquilaria sinensis*, 31 May 2018, CLZhao 6610 (SWFC 006610; MK802139); CLZhao 6612 (SWFC 006612; MK802141); CLZhao 6613 (SWFC 006613; MK802142); CLZhao 6614 (SWFC 006614; MK802143).

Discussion

In the present study, a new species, *Septobasidium aquilariae*, is described based on phylogenetic analyses and morphological characters.

Phylogenetically, *S. aquilariae* is closely related to "*S. cokeri*," *S. hainanense*, and *S. maesae* (Fig. 1). But morphologically "*S. cokeri*" differs from *S. aquilariae* by its pure white hymenial surface and restricted growth on *Quercus rubra* (Gómez & Henk 2004); *S. hainanense* differs in its purple hymenial surface and larger (25–36 × 7–13 μm) basidia (Lu & Guo 2010a); and *S. maesae* differs by its perennial basidiocarps peeled off after maturity and larger (28–55 × 7.5–11.5 μm) basidia (Lu & Guo 2009a).

Several species found in China are morphologically similar to *S. aquilariae*. *Septobasidium broussonetiae* C.X. Lu & al. is distinguished by its cracking basidiocarps and growth on *Broussonetia papyrifera* (Lu & al. 2010); *S. brunneum* Wei Li bis & L. Guo differs in its purple-brown hymenial surface with many cracks and growth on *Eurya* sp. (Li & Guo 2014); *S. capparis* S.Z. Chen & L. Guo differs by its thicker (≤2 mm thick) section and larger (45–56 × 8–12 μm) basidia (Chen & Guo 2012); *S. euryae-groffii* C.X. Lu & L. Guo is distinguished by its cinnamon to chestnut brown hymenium and growth on *Eurya groffii* (Lu & Guo 2010b); *S. fissuratum* Wei Li bis & L. Guo differs in its larger (32–45 × 6–9 μm) basidia and growth on *Castanea* sp. (Li & Guo 2013); *S. gaoligongense* C.X. Lu & L. Guo differs in its dark brown hymenium and thinner (260–580 μm) section (Lu & Guo 2010b).

Septobasidium guangxiense Wei Li bis & L. Guo differs from *S. aquilariae* in its yellowish brown hymenium with numerous fissures at maturity and larger (27–38 × 5–10 μm) basidia (Li & Guo 2014); *S. hoveniae* Wei Li bis & al. differs in its cinnamon-brown hymenium and growth on *Hovenia acerba* (Li & al. 2013); *S. polygoni* C.X. Lu & L. Guo differs in its white to cinnamon-brown hymenium and growth on *Polygonum campanulatum* (Lu & Guo 2010b); *S. reevesiae* S.Z. Chen & L. Guo differs in its thicker (1.65–2.20 mm) section and larger (37–55 × 8–13 μm) basidia and growth on *Reevesia longipetiolata* (Chen & Guo 2012); and *S. transversum* Wei Li bis & L. Guo differs in its cinnamon-brown basidiomata, its transverse

layer at the pillar bases, and larger (42–60 × 9–16 µm) basidia (Li & Guo 2014).

The diversity of *Septobasidium* is rich in China and 57 species have been reported, especially in subtropics and tropics (Lu & Guo 2009a,b, 2010a,b, 2011; Lu & al. 2010; Chen & Guo 2011, 2012; Li & Guo 2013, 2014). Several *Septobasidium* species have been described from Yunnan Province (Lu & Guo 2010b, 2011; Li & Guo 2013), and our new species, *S. aquilariae*, is also from Yunnan Province. It is expected that new taxa will be found after further research.

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Limacella bangladeshana, first record of the genus in Thailand

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Abstract—Mushroom specimens collected in Thailand were identified as *Limacella bangladeshana*, based on morphology and LSU and ITS sequence analyses. A full description and illustration are provided. This is the first record of the genus *Limacella* from Thailand.

Key words—*Agaricales*, *Amanitaceae*, gill fungus, taxonomy

Introduction

Limacella (*Amanitaceae*, *Agaricales*) was described by Earle (1909) with *L. delicata* (Fr.) Earle ex Konrad & Maubl. as the type species. This genus is mainly distributed in Europe and America, but some species are found in Asia (Smith 1945; Hongo 1978; Pegler 1983, 1986; Yang & Chou 2002; Neville & Poumarat 2004; Sato & al 2010; Ferreira & al. 2013; Kumari & al. 2013; Yang 2015; Hosen & Li 2017; Nascimento & Wartchow 2018; Yang & al. 2018). Approximately 47 taxa of *Limacella* are known (http://www.indexfungorum), but no *Limacella* species have been reported from Thailand (Chandrasrikul & al. 2011). During a taxonomic survey of macrofungi collected in northern Thailand, we found specimens that corresponded to the description of *L. bangladeshana*, previously reported from Bangladesh (Hosen & Li 2017). Herein we describe and illustrate the morphological characteristics of the Thai material and provide supporting evidence based on LSU and ITS gene sequence matches in GenBank.

Materials & methods

Morphology

Basidiomata were collected from the campus of Chiang Mai University, Chiang Mai Province, Thailand, and kept in plastic collection boxes until transported back to the laboratory. Macroscopic descriptions are based on observations of the fresh basidiomata. Color names and codes follow Kornerup & Wanscher (1978). The specimens were dried at 40–45 °C in an electric food dryer. The micromorphological data were derived from dried specimens mounted in 95% ethanol and rehydrated in distilled water, 3% KOH, or Melzer's reagent. Dimensions of anatomical features were calculated from at least 50 measurements of each structure. For basidiospores, Q represents the range of length/width ratios from individual spores and is the mean ± standard deviation of the ratios from all measured spores. Dried specimens were deposited in the herbarium of Research Laboratory for Excellence in Sustainable Development of the Biological Resources, Faculty of Science, Chiang Mai University, Thailand (SDBR-CMU).

Sequence analyses

Genomic DNA was extracted from fresh specimens using a Favorgen DNA Extraction Mini Kit following the manufacturer's instructions. The large subunit (LSU) region of ribosomal DNA (rDNA) was amplified by polymerase chain reaction (PCR) with LROR/LR5 primers, and the rDNA internal transcribed spacer (ITS) region was amplified with ITS4/ITS1F primers, under the following thermal conditions: 94 °C for 2 min; 35 cycles of 95 °C for 30 s, 52 °C for 30 s, 72 °C for 1 min; and 72 °C for 10 min. PCR products were checked under UV light on 1% agarose gels stained with ethidium bromide and purified using a NucleoSpin Gel and PCR Clean-up Kit following the Macherey-Nagel protocol. The purified PCR products were directly sequenced according to the Sanger method by 1ST Base Company in Kembangan, Malaysia, using the same PCR primers cited above. Sequences were used to query GenBank database via BLAST (http://blast.ncbi.nlm.nih.gov/Blast.cgi).

Taxonomy

Limacella bangladeshana Hosen, Phytotaxa 332: 281 (2017). Fig. 1

Pileus 20–50 mm diam., subconical to sub-hemispherical, becoming planoconvex, surface dry, orange white (5A2) to brown (7E4), slightly darker at the centre; margin non-striate, with brownish orange (6C4) to light orange (5A4) at edge, covered with white velvety to cottony squamules. Context 5–8 mm thick at the center of the pileus, white, unchanging when cut or bruised. Lamellae 22–30 × 7–10 mm, free, white to brownish orange (6C4) or brown (7E4) to dark brown (7F4) when dried. Stipe 25–50 × 5–12 mm, cylindrical to subcylindrical, slight swollen at base, dry, not slimy,

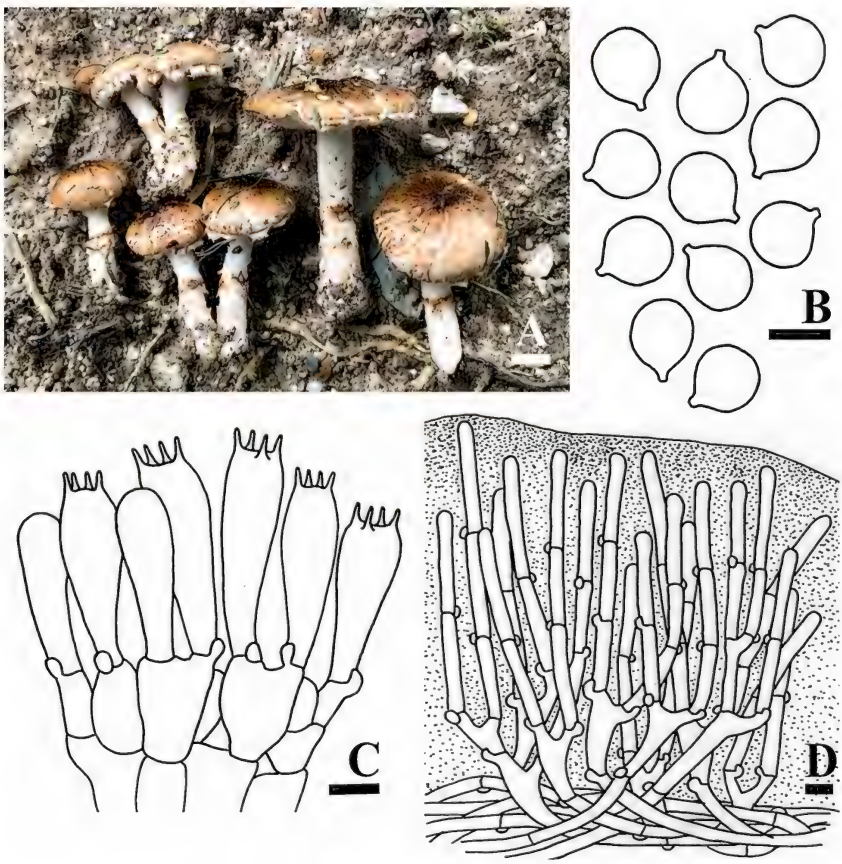

Fig. 1. *Limacella bangladeshana* (SDBR-CMU-JK0146).
A. basidiomata; B. basidiospores; C. basidia; D. pileipellis.
Scale bars: A = 10 mm; B, C = 5 μm; D = 10 μm.

surface covered with fibrillose or floccose squamules, white to brownish orange (6C4). Annulus absent.

Basidiospores 3–5 × 3–4.5 μm, Q = 1.00–1.11, = 1.04 ± 0.06, globose to (rarely) subglobose, hyaline, inamyloid, thin-walled, smooth; apiculus cylindrical to subcylindrical ≤1.2 μm long. Basidia 20–30 × 5–8 μm, clavate, hyaline, thin-walled, 4-spored, with sterigmata ≤4 μm long, with basal clamp connections. Subhymenium ≤35 μm thick, with 2–3 layers of inflated to subglobose cells, thin-walled, hyaline. Hymenophore trama

bilateral, filamentous hyphae 3–9 µm diam. mixed with inflated cells 15–32 × 10–20 µm. Lamellar edge fertile. Cheilocystidia and pleurocystidia absent. Pileipellis an ixo-trichodermium composed of more or less erect hyphae embedded in a gelatinized matrix, hyphae septate, hyaline, cylindrical, branched, with terminal cell 25–75 × 5–8 µm, clamp connections present. Stipe surface hyphae interwoven, filamentous, hyaline, thin-walled 3–5 µm diam., cells not inflated; stipe trama hyphae longitudinally arranged, 4–8 µm diam., mixed with acrophysalidic cells 10–16 µm diam. thin-walled, hyaline to pale yellow, clamp connections rare.

Specimens examined—**THAILAND, Chiang Mai Province, Muang District,** Chiang Mai University, 18°48′03″N 98°57′21″E, elevation 334 m, on soil, 2 June 2018, J. Kumla & N. Suwannarach (SDBR-CMU-NK0356; GenBank MK288133, MK290392); 3 June 2018, J. Kumla (SDBR-CMU-JK0146, GenBank MK290393, MK290394).

Molecular analysis

The LSU and ITS sequences of specimens SDBR-CMU-NK0357 and SDBR-CMU-JK0146 were deposited in GenBank. Our LSU and ITS sequences were 100% similar to *L. bangladeshana* ex-type sequences KR816866 and KR816865.

Discussion

The agaricoid basidiomata, slightly glutinous pileus, a fertile lamellar edge, lack of annulus, a stipe that is not viscid, and a trichodermium pileipellis embedded in a gelatinous matrix support the placement of our collections in *Limacella* (Singer 1986, Tulloss & al. 2016). According to the descriptions provided by Singer (1986), this genus is divided into two sections based mainly on the stipe characters. There are *L.* sect. *Lubricae* (viscid or glutinous stipe) and *L.* sect. *Limacella* (dry stipe). Based on its dry stipe, *L. bangladeshana* belongs to *L.* sect. *Limacella* (Hosen & Li 2017).

Thirteen *Limacella* species have been reported from Asia: *L. anomologa* (Berk. & Broome) Pegler, *L. asperulospora* Corner, *L. bangladeshana*, *L. glioderma* (Fr.) Maire, *L. illinita* (Fr.) Maire, *L. magna* B. Kumari & R.C. Upadhyay, *L. myxodictyon* (Berk. & Broome) Pegler, *L. ochraceolutea* P.D. Orton, *L. olivaceobrunnea* Hongo, *L. quilonensis* Sathe & J.T. Daniel, *L. singaporeana* Corner, *L. subglischra* (S. Imai) S. Ito, and *L. taiwanensis* Zhu L. Yang & W.N. Chou (Corner 1994, Hosen & Li 2017, Imai 1938, Kumari & al. 2013, Pegler 1986, Sathe & Daniel 1981, Sato & al. 2010, Yang 2015, Yang & Chou 2002). *Limacella asperulospora*, *L. glioderma, L. illinita*, *L. myxodictyon*,

L. ochraceolutea, *L. olivaceobrunnea*, and *L. singaporeana* with buff white, dark cinnamon to reddish brown, pale brown, dark reddish brown, dark yellowish brown colors and larger (3.5–12.5 × 3–7 µm) basidiospores with higher (1.05–1.2) values (Hongo 1978, Pegler 1986, Corner 1994, Yang 2015) are distinguished from *L. bangladeshana*, with orange white to brown basidiomata and globose basidiospores (3–5 × 3–4.5 µm) with a lower value (1.04) (Hosen & Li 2017). The yellowish to pale orange basidiomata distinguish *L. subglischra* (Imai 1938) from *L. bangladeshana*. Shorter basidiospores separate *L. bangladeshana* from *L. anomologa* (4–5.7 × 2.7–3.3 µm), *L. magna* (7–12.5 × 5–7 µm), and *L. quilonensis* (7–10 × 3–4 µm) (Sathe & Daniel 1981, Pegler 1986, Kumari & al. 2013), while the subglobose basidiospores of *L. taiwanensis* (3–4.5 × 3–3.5 µm; Yang & Chou 2002) with a verruculose surface clearly distinguish that species from *L. bangladeshana*. The LSU molecular analysis supports the morphological differences between *L. bangladeshana* and other *Limacella* species (Hosen & Li 2017).

The LSU and ITS sequence matches in GenBank confirmed that the two Thai specimens belong to *L. bangladeshana*. Therefore, the combination of morphological and molecular characteristics supports the identification of *L. bangladeshana*, a new record in Thailand.

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New records of *Acarospora* and *Psora* from China

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Abstract—*Acarospora impressula, A. umbilicata, Psora gresinonis, and P. himalayana* are reported for the first time from China and *Psora decipiens* for the first time from Qinghai Province. Descriptions, illustrations, and distributions are given for each species.

Keywords —*Acarosporaceae,* East Asia, lichenized fungi, *Psoraceae,* taxonomy

Introduction

Acarospora (*Acarosporaceae, Acarosporales*) was established by Massalongo (1852). The genus is characterized mainly by crustose (often distinctly areolate or subsquamulose) thalli, 16–100+-spored asci with non-amyloid apical domes, and hymenium typically over 100 µm thick (Knudsen 2007, Fletcher & al. 2009). The genus contains about 200 species (Lücking & al. 2016), usually on siliceous rocks, rarely on calcareous rocks, wood, and soil, often in arid habitats (Knudsen 2007, Fletcher & al. 2009, Øvstedal & al. 2018). In China, 35 species have been reported (Dongling & al. 2017, Knudsen 2007, Wei 1991, Nurtai & al. 2019).

Psora (*Psoraceae, Lecanorales*) comprises 30 species growing on soil and rock, mainly in arid areas, in arctic to subtropical regions (Timdal 2002). The genus is characterized mainly by squamulose thalli, a hypothecium containing calcium oxalate crystals, porpidia-type asci, laminal pycnidia, and acrogenous bacilliform pycnoconidia. In China, 11 species have been reported (Abbas 1998, Mamut & Abbas 2016, Wei 1991).

[#]Chun-Xiao Wang & Chuan-Feng Zheng contributed equally to this manuscript.

In this paper we provide valuable information on *Acarospora* and *Psora* in China in preparation for a revised edition of Wei's (1991) book, An Enumeration of Lichens in China. Here, we identify four species new to the country—*Acarospora impressula*, *A. umbilicata*, *Psora gresinonis*, *P. himalayana*—and report *P. decipiens* for the first time from Qinghai Province.

Materials & methods

The specimens studied were collected in Inner Mongolia Autonomous Region (Neimenggu) and Qinghai Province, China, and are preserved in Lichen Section of the Botanical Herbarium, Shandong Normal University, Jinan, China (SDNU). The specimens were examined morphologically under a COIC XTL7045B2 stereomicroscope and Olympus CX41 polarizing microscope. Thallus and medulla were tested for identification with K (10% potassium hydroxide aqueous solution), C (saturated aqueous sodium hypochlorite solution), and I (Lugol's iodine). The lichen substances were identified using standardized thin layer chromatography techniques (TLC) with system C (Orange & al. 2001). The lichens were photographed using an Olympus DP72 camera attached to Olympus SZX16 and BX61 microscopes.

Taxonomy

Acarospora impressula Th. Fr., Lich. Scand. 1: 214 (1871) Fig. 1

Thallus areolate, rugulose, with cracks between areoles, 0.3–0.7 mm wide, 0.3–0.5 mm high. Upper surface brown, slightly white pruinose. Epinecral layer 20 µm. Cortex 22.5–37.5 µm thick. Algal layer uneven, interrupted by hyphal bundles, ≤175 µm thick, algal cells 10–17.5 µm in diam. Medulla white, plectenchymatous, ≤300 µm thick. Apothecia 0.36–0.41 mm wide, disc dark brown. Exciple hyaline, distinct, 2.5–125 µm wide. Epihymenium light yellow, 12.5–17.5 µm tall. Hymenium hyaline, 45–75 µm tall; paraphyses hyaline, simple or slightly branched, conglutinate. Asci hyaline, 62.5–75 × 15–17.5 µm, 100–200-spored; ascospores simple, ellipsoid, 2–3 × 5–6 µm. Subhymenium hyaline, 12.5–52.5 µm tall. Hypothecium hyaline, indistinct. Algal layer uneven, interrupted by hyphal bundles, ≤150 µm thick, algal cells 7.5–15 µm in diam. Medulla containing many crystals.

Chemistry—Thallus K–, C–, KC–, hymenium I+ blue; no secondary metabolites detected by TLC.

Specimen examined—**CHINA. Neimenggu,** Hu He Ba Shi Ge, alt. 1600 m, 16 Aug. 2011, D.B. Tong 20123540 (SDNU).

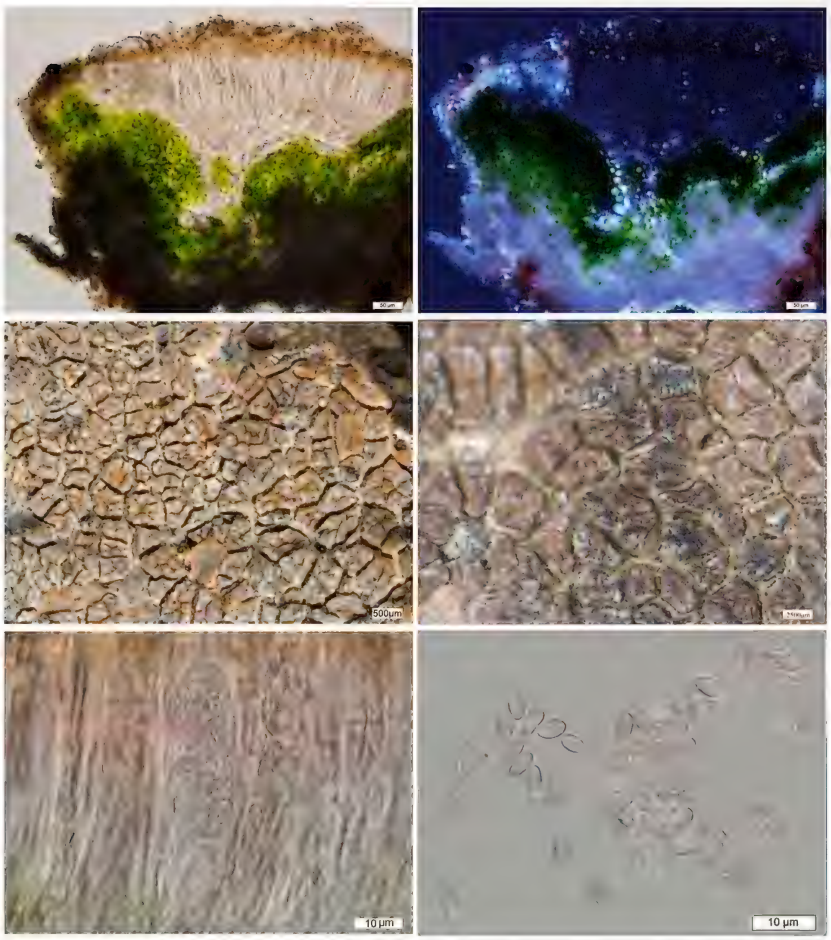

Fig. 1. ***Acarospora impressula*** (Tong 20123540, SDNU). A, B. Apothecia section; C. Thallus and apothecia; D. Apothecia; E. Asci; F. Ellipsoid ascospores.

Ecology & distribution—On siliceous or calcareous rock. Europe, Asia, North Africa, Greenland, North America, Australia (Temina & al. 2005, Øvstedal & Gremmen 2014). New to China.

Comments—Through studying *Acarospora* from China, it was found that *A. brevilobata* H. Magn. and *A. gobiensis* H. Magn. have similar ascospores to *A. impressula* but differ in their thallus, which is circular in *A. brevilobata* and yellow in *A. gobiensis* (Abbas 1998, Temina & al. 2005). Our specimen

closely matches the modern description of *A. impressula* in Øvstedal & Gremmen (2014).

Acarospora umbilicata Bagl., Mém. R. Accad. Sci. Torino, Ser. 2, 17: 397 (1857) FIG. 2

THALLUS squamulose, convex, 0.4–1.4 mm wide, 0.1–0.3 mm high. Upper surface grey-brown, densely white-pruinose. Epinecral layer 20–25 µm tall. Cortex 22.5 µm thick, with crystals. Algal layer even, 30–112.5 µm thick, algal cells 7.5–17.5 µm in diam. Medulla white, plectenchymatous, scattered to contiguous with crystals in longitudinal sections. APOTHECIA black, disc depression 0.19–1.28 mm. Exciple hyaline, distinct, 25–38 µm wide. Epihymenium brown, 20–30 µm tall. Hymenium hyaline, 37.5–100 µm tall, paraphyses hyaline, simple, apex expanded, conglutinate. Asci 87.5–95 × 20–22.5 µm, 100–200-spored; ascospores simple to 1-septate, 4–5 × 1.5–2 µm, ellipsoid. Subhymenium hyaline, 25–40 µm tall. Hypothecium hyaline, 35–60 µm tall. Algal layer uneven, interrupted by hyphal bundles, contains crystals, ≤100 µm thick, algal cells 7.5–12.5 µm in diam. Medulla containing many crystals, 50–162.5 µm tall.

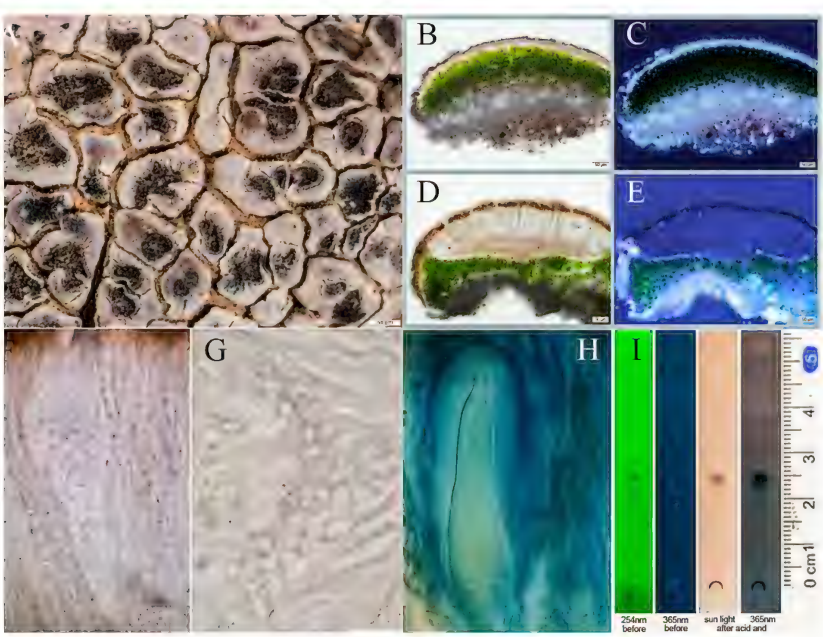

FIG. 2. ***Acarospora umbilicata*** (Tong 20123044, SDNU). A. Thallus and apothecia; B, C. Thallus section; D, E. Apothecia section; F. Asci; G. Ascospores; H. Asci I+ blue; I. TLC chromatograms.

Chemistry—Thallus K–, C+ red, KC+ red; hymenium I+ blue. Secondary metabolites: gyrophoric acid.

Specimen examined — **China. Neimenggu**, Ho-lan Mountains, alt. 1500 m, 19 Aug. 2011, D.B. Tong 20123044 (SDNU).

Ecology & distribution—On siliceous rock. Europe, Asia, North Africa, Canary Islands, Madeira Islands (Temina & al. 2005, Galloway 2007). New to China.

Comments—*Acarospora fulva* N.S. Golubk., *A. fuscata* (Nyl.) Th. Fr., *A. glypholecioides* H. Magn., and *A. jenisejensis* H. Magn. are similar to *A. umbilicata* by the C+ red reaction indicating gyrophoric acid as secondary metabolites. However their thalli differ, lacking pruina in *A. fuscata*, colored yellow in *A. fulva*, and wider in *A. glypholecioides* and *A. jenisejensis*. *Acarospora glypholecioides* and *A. jenisejensis* are further distinguished by their shorter ascospores (*A. glypholecioides*, 3–3.5 × 1.7 µm; *A. jenisejensis*, 3–3.5 × 2.5–3 µm; Abbas 1998, Temina & al. 2005, Galloway 2007, Knudsen 2007). Our specimen agrees closely with modern descriptions of *A. umbilicata* (Timdal 1987, Galloway 2007).

Psora decipiens (Hedw.) Hoffm., Descr. Pl. Cl. Crypt. 2: 68 (1794) Fig. 3a–d

Squamules ≤6 mm wide, adnate, scattered to contiguous, concave to convex; upper surface bright red, epruinose or partly to entirely white pruinose, sparingly fissured; margin white, slightly up-turned, soon becoming crenulate; upper cortex ≤150 µm thick, containing crystals of calcium oxalate; medulla, containing calcium oxalate crystals; lower cortex poorly developed or absent. Apothecia ≤2.5 mm diam., marginal, immarginate, black, epruinose. Asci 8-spored, ascospores ellipsoid, simple, hyaline, 10–15 × 6–9 µm. Pycnidia not seen.

Chemistry—Thallus K–, C–, KC–, hymenium I+ blue; no secondary metabolites detected.

Specimen examined: **China. Qinghai**, Haibeizhan Fengxiakou alpine meadow, alt. 3280 m, 6 Aug. 2007, C. Yuan 20070787 (SDNU).

Ecology & distribution—On soil. Africa, Asia, Australia, Europe, New Zealand, and North and South America (Timdal 2002, Galloway 2007). New to Qinghai Province.

Comments—*Psora decipiens* is characterized by its bright red squamules, marginal apothecia, white margin, and absence of chemical substances. It is closely related to *P. crenata*, which differs by its broader and thicker (10 mm)

squamules, usually with a regular central depression, and a down-turned, more or less entire margin. Our specimen is closely similar to modern descriptions of *P. decipiens* (Timdal 1987, Galloway 2007).

Psora gresinonis B. de Lesd., Bull. Soc. Bot. France 77: 614 (1930) FIG. 3E–H

SQUAMULES discrete, attached to the substrate, concave, 2–3 mm wide; upper surface dark brown; margin darker with upper side; upper cortex ≤60 µm thick, lacking calcium oxalate crystals; lower cortex poorly developed. APOTHECIA ≤1.4 mm diam., laminal or submarginal, immarginate, black. ASCI 8-spored, ascospores ellipsoid, simple, hyaline, 10–15 × 7.5–10 µm. PYCNIDIA not seen.

CHEMISTRY—Cortex K–, C–, medulla C–, K+ red, KC+ red; norstictic acid detected by TLC.

SPECIMEN EXAMINED: **CHINA. QINGHAI,** Haibeizhan Fengxiakou alpine meadow. alt. 3250 m, 6 Aug. 2007, Z.S. Sun 20070741 (SDNU).

ECOLOGY & DISTRIBUTION — On soil. Italy, France (Timdal 1984). New to China.

COMMENTS—*Psora gresinonis* is characterized by its dark brown squamules, black margin, and norstictic acid. The species is closely related to *P. vallesiaca* (Schaer.) Timdal and *P. tenuifolia* Timdal, which are distinguished by their reddish brown squamules and white margin (Timdal & Zhurbenko 2004). Our specimen agrees with the original description of *P. gresinonis* by Bouly de Lesdain (1930).

Psora himalayana (C. Bab.) Timdal, Bryologist 89: 262 (1987 ["1986"]) FIG. 3I–L

SQUAMULES ≤4 mm wide, ascending and imbricate; upper surface medium brown or reddish brown to dark brown, epruinose or more rarely faintly white pruinose (especially along the margin); margin white, slightly up-turned, underside brown in center, white near the margin; upper cortex ≤150 µm thick, sometimes containing calcium oxalate crystals; medulla sometimes containing calcium oxalate crystals; lower cortex not sharply delimited from the medulla, containing calcium oxalate crystals. APOTHECIA ≤2 mm diam., laminal, immarginate, black, epruinose. ASCI 8-spored, ascospores ellipsoid, simple, hyaline, 12.5–17 × 5–9 µm. PYCNIDIA not seen.

CHEMISTRY—Thallus K–, C–, KC–, hymenium I+ blue; no substances detected by TLC.

SPECIMEN EXAMINED: **CHINA. QINGHAI,** National Highway 109, Mt. Xiangpi, alt. 3520 m, 15 Aug. 2007, Y.D. Du & X.L. Shi 20071940 (SDNU).

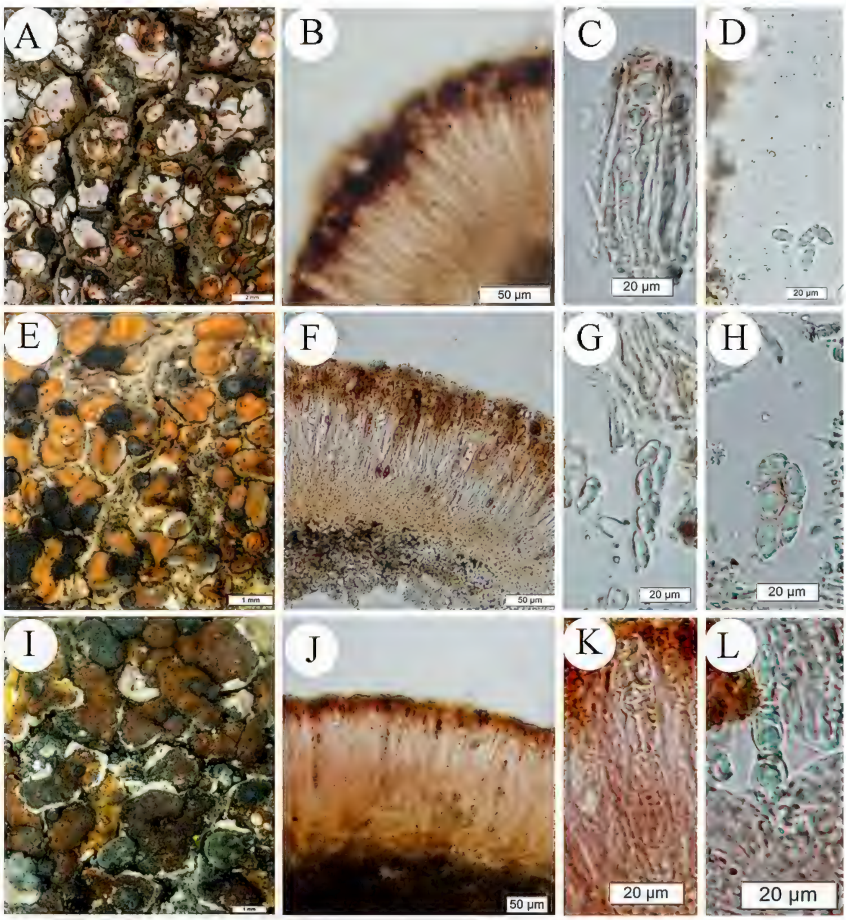

FIG. 3. ***Psora decipiens*** (Yuan 20070787, SDNU). A. Thallus and apothecia; B. Apothecia section; C. Asci; D. Ascospores. ***Psora gresinonis*** (Sun 20070741, SDNU). E. Thallus and apothecia; F. Apothecia section; G. Asci; H. Ascospores. ***Psora himalayana*** (Du & Shi 20071940, SDNU). I. Thallus and apothecia; J. Apothecia section; K. Asci; L. Ascospores.

ECOLOGY & DISTRIBUTION—On soil. Asia, Europe, and western North America (Timdal 2002). New to China.

COMMENTS—*Psora himalayana* is characterized by squamules distinctly white pruinose along the margin and calcium oxalate crystals present in the medulla and/or the lower cortex. The species is closely related to *P. globifera* (Ach.) A. Massal., which differs by its pruina distributed mainly on the upper side near the squamule margins, and its pale to medium brown lower side near the

squamule margins (Timdal 1987). *Psora vallesiaca* differs from *P. himalayana* mainly in having norstictic acid (Timdal & al. 2016). Our specimen agrees with the original description of *P. himalayana* by Timdal (1987).

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Phylogenetic affinity and taxonomic reassessment of *Pseudoidium kalanchoes*

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Abstract—*Pseudoidium kalanchoes*, retrieved from powdery mildew on *Kalanchoe* spp. in Asia, has been re-examined and reassessed based on phylogenetic analyses of the ITS and 28S rDNA regions. The results confirmed that sequences retrieved from Asian *Kalanchoe* powdery mildew have 100% congruence with sequences obtained from *Erysiphe sedi* on *Sedum* spp. A German collection of *P. kalanchoes* on *Kalanchoe blossfeldiana* was morphologically and genetically examined and analyzed and is designated as neotype with an ex-neotype reference sequence. Morphologically, the asexual morph on *Kalanchoe* spp. agrees with the asexual morph of *E. sedi*. Consequently, *P. kalanchoes* is reduced to synonymy with *E. sedi*.

Key words —*Erysiphales*, "*Oidium calanchoeae*," phylogeny

Introduction

Lüstner (1935) introduced the name "*Oidium calanchoeae*" for an asexual powdery mildew on *Kalanchoe* sp. (very probably *K. blossfeldiana* Poelln.) from Germany. He failed to present the Latin description or diagnosis required by ICN (Shenzhen) Art. 39.1, making his binomial invalid; and his epithet "*calanchoeae*" required a twofold correction, to *kalanchoes*, an orthography based on the accepted name of the host genus (ICN Art. F.9.1), *Kalanchoe* Adans. 1763 (instead of *Calanchoe* Pers. 1805), and use of the correct genitive case ending (ICN Art. 32.2). Braun (1987: 602) validated

Oidium kalanchoes by adding a Latin description and an effective typification based on Lüstner's original material (although this could not be traced). The corrected orthography was first published in Braun & al. (2003), and Braun & Cook (2012) later combined this species in *Pseudoidium* Y.S. Paul & J.N. Kapoor.

Pseudoidium kalanchoes has been reported (sometimes under synonyms or misdeterminations) from Asia, Australasia, Europe, and North America on crassulacean hosts: *Crassula ovata, Kalanchoe blossfeldiana, K. (Bryophyllum) daigremontiana, K. (Bryophyllum) delagoensis, K. (Bryophyllum) pinnata, Kalanchoe* spp., and *Sedum praealtum* (Adhikari 2017; Amano 1986; Boesewinkel 1980; Braun 1987, 1995; Braun & Cook 2012; Braun & al. 2003; Cho & al. 2012; Fang & al. 2017; Ialongo 1992; Jage & al. 2010; Liu 2010; Nagy 1975; Tang & al. 2016; see also Table 1). Chinese collections on *K. blossfeldiana* and *K. pinnata* were assigned to *Erysiphe sedi* on the basis of ITS analyses (Tang & al. 2016; Fang & al. 2017). The three hosts classified in *Kalanchoe* sect. *Bryophyllum* are retained in *Kalanchoe* (rather than in genus *Bryophyllum*) on the basis of phylogenetic analyses (Gehrig & al. 2001, Mort & al. 2010).

The present examinations aimed at re-examining and analyzing German collections through morphological and molecular methods in order to clarify the identity of *Oidium kalanchoes* and to stabilize the application of this name by neotypification with an ex-neotype reference sequence.

Materials & methods

Collection and maintenance of powdery mildew isolates

The powdery mildew isolate used for sequence analyses was collected from naturally infected *Kalanchoe blossfeldiana* plants from Germany in January 2018.

Morphological characterization and molecular analysis described below were performed using the single spore isolate JKI-GFZ-C20-EM25A, obtained by transferring a single conidium onto washed cut-off *Kalanchoe* leaves. Inoculated cuttings were incubated in plastic boxes at room temperature and natural day–night periods for two to three weeks until colonies could be detected. To ensure a pure isolate, four subsequent sub-cultures were performed. Uninoculated leaves served as controls. Artificially infected leaves were deposited at the Herbarium of the Institute of Biology, Department of Geobotany and Botanical Garden, Martin Luther University Halle-Wittenberg, Germany (HAL) as voucher HAL 3298 F.

Morphological characterization

For morphological characterization, fresh powdery mildew structures were stripped off the leaf with sticky tape and mounted in water. Herbarium samples

were mounted in lactic acid and gently heated. Mycelia from the upper and lower leaf surfaces were inspected. Morphological characteristics covering size and shape of conidia (n ≥100) and conidiophores (n ≥50), position of the basal septum, shape and position of hyphal appressoria, and presence or absence of fibrosin bodies were assessed. Conidial length and width were analyzed following Frank (1990) with modifications: the applied values indicate the minimum, lower limit, upper limit, and maximum values; lower and upper limits indicate the range of 90% of all values (not 95% as described by Frank 1990).

All morphological characteristics were examined using a Zeiss® Axio Imager.A1 standard light microscope equipped with an AxioCam MRc5 camera and differential interference contrast at 200×, 400×, and 1000×. Measurements were made and images were taken with the calibrated Axiovision software rel. 4.8, and the images were processed using Adobe® Photoshop CS4 software version 11.0.

Conidial germination patterns were assessed following the method of Zaracovitis (1965) with slight modifications. Preferably young conidia (~ 24 h) were dusted onto microscope slides and incubated in a moist chamber at 20 ± 1 °C in the dark for 24–48 h and analysed and documented as above. The patterns were compared with those described in Cook & Braun (2009).

Molecular characterization

Total DNA was extracted from conidia and mycelia using the Qiagen DNeasy plant mini kit following the manufacturer's instructions with slight modifications. The internal transcribed spacer (ITS) was amplified using the primers ITS5 and PM6 (Takamatsu & Kano 2001), and the 28S rRNA was amplified using PM5 (Takamatsu & Kano 2001) and NLP2 (Hirose & al. 2005). The reaction mix contained Hot FirePol Mastermix (containing 7.5 mM $MgCl_2$), 0.2 µM of each primer, and 4 µl template DNA in a total volume of 50 µl. PCR was performed in a MyCycler thermal cycler with an initial denaturation step at 95 °C for 13 min; followed by 40 cycles of 30 s at 94 °C for denaturation, 30 s/50 s (ITS/28S rRNA) at 52 °C for annealing, and 30 s/50 s (ITS/28S rRNA) at 72 °C for extension; and a final extension for 10 min at 72 °C. PCR products were purified using a MSB Spin PCRapace Kit. Fragments were bidirectionally sequenced twice with the same primers used for PCR by LGC Genomics GmbH. A contig was generated and edited using CLC Main Workbench 8.1 following the EPPO recommendations for sequence analysis (OEPP/EPPO 2016). The consensus sequence was deposited in GenBank under the accession number MK411006.

The sequence obtained for the isolate JKI-GFZ-C20-EM25A was aligned to sequences of three *Erysiphe sedi* isolates and 12 additional isolates from the *Erysiphe aquilegia* clade (see Takamatsu & al. 2015 for further details of the sequences concerned) spanning the same region using CLC Main Workbench 8.1 with the settings gap open cost 10.0 and gap extension cost 1.0 and the very accurate alignment mode. *Erysiphe linderae* (LC010067; Abasova & al. 2018) was chosen as outgroup taxon. The alignment was manually refined using CLC Main Workbench.

A phylogenetic tree was constructed using the Neighbor-Joining method and the nucleotide substitution model Kimura's (1980) two parameter model with a

transition/transversion ratio of 2.0 (Fig. 1). The strength of the internal branches of the resulting tree was tested with bootstrap analysis using 1000 replications (CLC Main Workbench 8.1).

Results

Phylogenetic analysis

Sequence data including genes for ITS1, 5.8S rRNA, ITS2, 28S rRNA (partial and complete) obtained from the isolate JKI-GFZ-C20-EM25A (MK411006) showed 100% identity to three sequences of *E. sedi* (LC010045, LC010046, LC010047) spanning the same region deposited in GenBank (Fig. 1). They were also identical to sequences of *E. hommae* (LC009926) and *Pseudoidium hortensiae* (LC009915). All sequences belong to the *Erysiphe aquilegiae* clade (see Takamatsu & al. 2015), which is characterized by insufficient resolution on species level, indicating that the resolution of the region analyzed is not high enough to distinguish all members of this clade. However, both morphological characteristics and host range support assignment of JKI-GFZ-C20-EM25A to *E. sedi*.

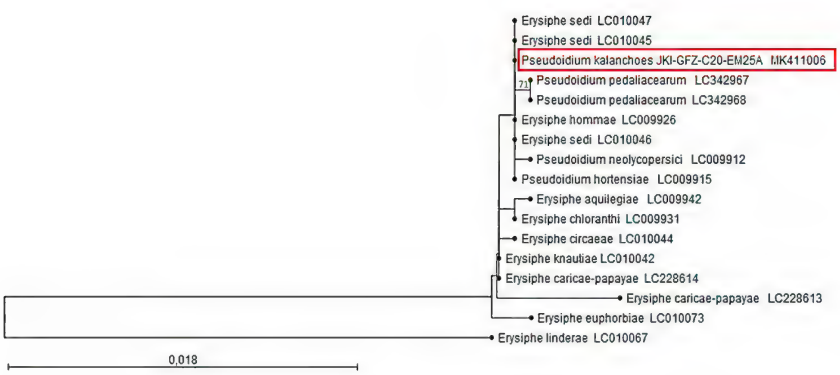

Fig. 1. Phylogenetic analysis (combined data of ITS1, 5.8S rRNA, ITS2, and 28S rRNA complete and partial sequences) for the isolate JKI-GFZ-C20-EM25A (framed in red) including 15 selected sequences of the *Erysiphe aquilegiae* clade. The bootstrap support value for maximum likelihood >70% is presented above the node. The tree is rooted to *Erysiphe linderae* (LC010067).

Morphology

The following description is based on collections on *Kalanchoe* spp. (Eliade 1990, Bolay 2005, Liu 2010, Braun & Cook 2012, present examinations):

Erysiphe sedi U. Braun, Feddes Repert. 92(7–8): 502, Sept. 1981. FIG. 2

= *Erysiphe sedi* R.Y. Zheng & G.Q. Chen, Sydowia 34: 253, 31 Dec. 1981, nom. illeg.

= *Oidium kalanchoes* Lüstner ex U. Braun, Beih. Nova Hedwigia 89: 602, 1987, as "*calanchoeae*" [validation of "*Oidium calanchoeae*" Lüstner, Nachrichtenbl. Deutsch. Pflanzenschutzdienst 15(4): 41, 1935, nom. inval., ICN (Shenzhen) Art. 39.1]. TYPE: Germany, on leaves of *Kalanchoe blossfeldiana*, 1935, G. Lüstner (**holotype; not preserved**). Germany, Niedersachsen, Braunschweig, Julius Kühn Institute, greenhouse, on living leaves of *Kalanchoe blossfeldiana*, Jan. 2018, M. Götz (**neotype**, HAL 3298 F, **designated here** MBT 385509; GenBank MK411006.)

≡ *Pseudoidium kalanchoes* (Lüstner ex U. Braun) U. Braun & R.T.A. Cook, Taxon. Man. *Erysiphales*: 608, 2012.

MYCELIUM amphigenous, also caulicolous, forming white or grayish white patches, sometimes confluent or effuse, persistent. HYPHAE straight to flexuous-sinuous, branched, (2–)4–8(–10) µm wide, septate, hyaline, thin-walled, smooth. HYPHAL APPRESSORIA solitary or in opposite pairs, 1–4 per cell, almost nipple-shaped to distinctly lobed, 5–10 µm diam. CONIDIOPHORES arising from the upper surface of mother cells, erect, 40–200 µm long. FOOT-CELLS cylindrical, straight, (15–)18–50(–60) × 6–11 µm, followed by (1–)2(–3) cells, usually about as long as the foot-cell, shorter or even longer, occasionally followed by a very long cell up to 90 µm, forming conidia singly. CONIDIA cylindrical to ellipsoid, (22–)30–55(–85) × (10.5–)14–22(–25) µm, length/width ratio (1.5–)1.7–3.2(–3.8). GERM TUBES *Pseudoidium* type, occasionally in a longitubus pattern, usually with a single perihilar germ tube, rarely with 2–3 germ tubes, usually short to moderately long, straight, unbranched and aseptate, occasionally with a single septum, very rarely branched, apex usually with a lobed appressorium, sometimes only swollen and unlobed.

SPECIMENS EXAMINED—**GERMANY. HESSEN**: sine loco: on living leaves of *Kalanchoe blossfeldiana*, 1.IV.1998, J. Dalchow (HAL 405 F); Wiesbaden, on living leaves of *Crassula ovata*, 12.V.2003, S. Krause (HAL, s.n.). **NIEDERSACHSEN**: Braunschweig, on living leaves of *Crassula ovata*, I.2003, U. Brielmaier-Liebetanz (HAL, s.n.); Braunschweig, Julius Kühn Institute, greenhouse, on living leaves of *Kalanchoe blossfeldiana*, I.2018, M. Götz (HAL 3298 F, neotype).

Discussion

Until the application of molecular methods for the purpose of identification of powdery mildew species, the names *Pseudoidium/ Oidium kalanchoes* were widely used for an asexual morph occurring on *Kalanchoe blossfeldiana* and other *Kalanchoe* species (including *Bryophyllum*) as well as *Crassula ovata* (Eliade 1990, Braun 1995, Braun & al. 2003, Bolay 2005, Liu 2010, Braun & Cook 2012). First molecular

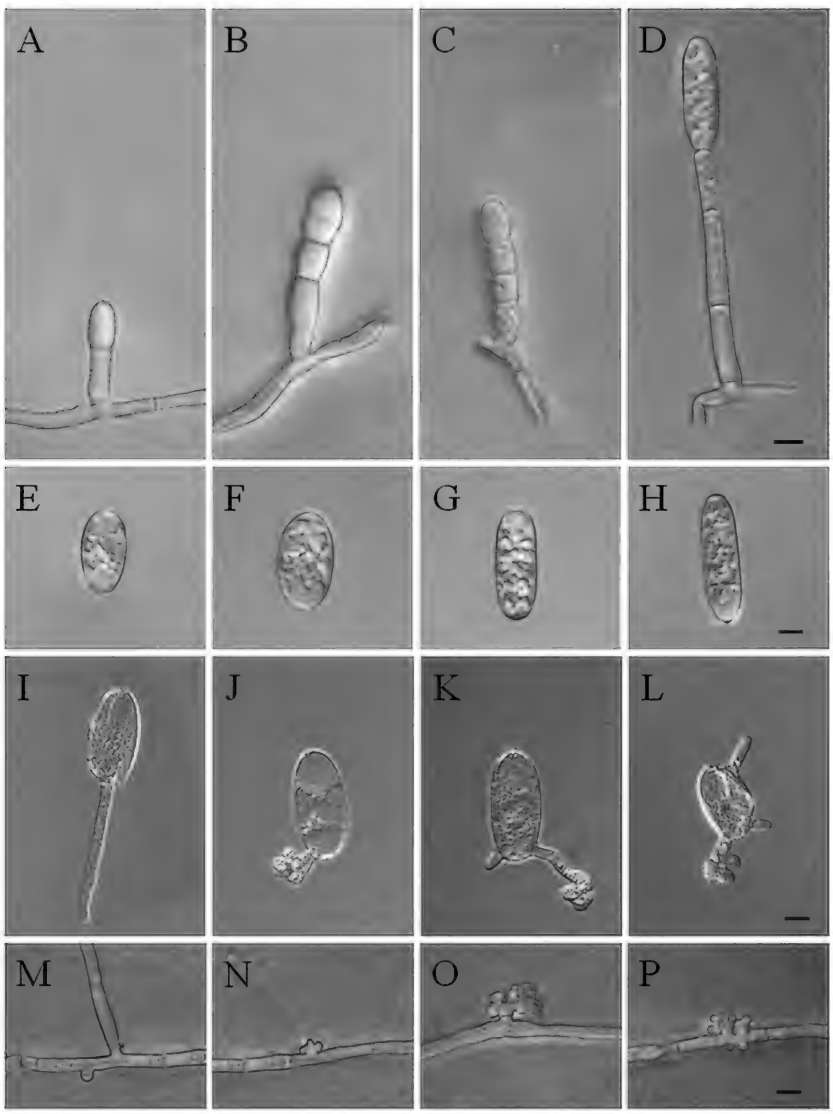

Fig. 2. *Pseudoidium kalanchoes* on *Kalanchoe blossfeldiana* (neotype, HAL 3298 F): A–D. Conidiophores; E–H. Conidia; I–L. Conidial germination types in vitro [I. Longitubus pattern; J–L. *Pseudoidium* type]; M–P. Hyphal appressoria (background removed with Adobe Photoshop to clarify relevant features of the conidiophores). Scale bars = 10 μm.

examinations of this powdery mildew in Asia on *Kalanchoe* spp. raised serious doubts as to the taxonomic status and true affinity of this anamorph-typified powdery mildew species (Cho & al. 2012, Tang & al. 2016, Fang & al. 2017). On the basis of analyses of ITS data and corresponding morphological traits, these authors identified Chinese and Korean powdery mildew specimens on *Kalanchoe* spp. as *Erysiphe sedi*. Therefore, it was logical to assume that *P. kalanchoes* must be considered a heterotypic synonym of *E. sedi*. In order to confirm this assumption, it was necessary to neotypify *P. kalanchoes* (type not preserved) with a German collection on *K. blossfeldiana* and to retrieve an ex-neotype reference sequence. A corresponding neotype has been designated and morphologically as well as phylogenetically examined. The morphology of the neotype material coincided with the asexual morph of *E. sedi* on *Sedum* spp. and the ex-neotype ITS1-5.8S rRNA-ITS2-28S rRNA sequence shows a congruence of 100% with sequences retrieved from *E. sedi* on *Sedum* and *Kalanchoe* spp. The results of a combination of morphological and phylogenetic analyses justify reducing *P. kalanchoes* to synonymy with *E. sedi*, while the limited resolution of ITS data on species level within the *E. aquilegiae* clade (see Takamatsu & al. 2015) may not be concealed. Multilocus analyses of this clade are necessary but not yet available.

Table 1. Host range and distribution of *Erysiphe sedi* on *Kalanchoes* spp.

Host	Country	Reference
Crassula ovata	Germany	Braun & al. 2003
Kalanchoe blossfeldiana	South Korea; Australia; Germany, Hungary, Norway, Romania, Switzerland; USA	von Arx 1952, Nagy 1975, Spencer 1978, Amano 1986, Ialongo 1992, Braun 1995, Jage & al. 2010
Kalanchoe daigremontiana; ≡ *Bryophyllum daigremontianum*	China, Nepal	Liu 2010 Adhikari 2017
Kalanchoe delagoensis; ≡ *Bryophyllum delagoense;* = *Kalanchoe tubiflora*	Germany; New Zealand	Braun & al. 2003; Boesewinkel 1980, as "*Microsphaera polonica*"
Kalanchoe pinnata; ≡ *Bryophyllum pinnatum*	China	Tang & al. 2016
Kalanchoe spp. [incl. hybrids]	Italy, Netherlands; Canada	Amano 1986
Sedum praealtum	New Zealand	Boesewinkel 1980, as "*Microsphaera polonica*"

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Beltraniomyces panthericolor and *B. pulcher* spp. nov. from Brazil

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Abstract—Two new *Beltraniomyces* species found on decaying leaves and wood in Brazil are described and illustrated. *Beltraniomyces panthericolor* is distinguished by biconic, brown conidia with multiple, irregular, dispersed, smoky to gray-brown spots that resemble leopard spots. *Beltraniomyces pulcher* is characterized by biconic conidia with rounded to subobtuse apices.

Key words—biodiversity, conidial fungi, hyphomycetes, *Pezizomycotina,* taxonomy

Introduction

Asexual fungi belong primarily to *Ascomycota* and are abundant in nature as decomposers of litter (Seifert & al. 2011). In Brazil, research involving asexual ascomycetous decomposers has concentrated in the Caatinga and Mata Atlântica biomes (Santa Izabel & Gusmão 2018, Barbosa & al. 2013). The monotypic genus *Beltraniomyces* Manohar. & al. was originally described from dead unidentified twigs in India and is characterized by macronematous, mononematous conidiophores with polyblastic, sympodial conidiogenous cells producing biconic conidia with central hyaline transverse bands (Manoharachary & al. 2003). The genus is typified by *B. lignicola* Manohar. & al., and no additional species have been described (Wijayawardene & al. 2017).

Two undescribed species resembling *Beltraniomyces* that were found during a survey of asexual fungi on decaying plants from Brazil are described and illustrated here. A key for the three *Beltraniomyces* species is also presented.

Materials & methods

Expeditions were made in Fazenda São Nicolau (Cotriguaçu, Mato Grosso), Parque Estadual Cristalino (Novo Mundo, Mato Grosso), and Brejo Paraibano (Areia, Paraíba) to collect leaf litter and wood debris. Samples were placed in paper bags, taken to the laboratory, and processed as described in Castañeda-Ruiz & al. (2016). Reproductive structures were placed on slide prepared with PVL resin (polyvinyl alcohol, lactic acid, and phenol), measured, and photographed using a microscope equipped with phase contrast. The type specimens were deposited in the Herbario Centro-Norte Mato-Grossense, Sinop, Mato Grosso, Brazil (CNMT), and Herbario Jayme Coelho de Moraes, Areia, Paraiba, Brazil (EAN).

Taxonomy

Beltraniomyces panthericolor L.A. Costa, G.G. Barreto, F.R. Barbosa, Fiuza, R.F. Castañeda, **sp. nov.** FIG. 1

MB 830313

Differs from *Beltraniomyces lignicola* by its longer, brown conidia with multiple smoky or gray-brown spots covering the conidial body.

TYPE: Brazil, Paraiba State, Areia, Arboreto Jayme Coelho de Moraes, 7°02′04″S 35°48′28″W, on dead leaves of *Clusia* sp. (*Clusiaceae*), 20.IX.2018, coll. L.A. Costa (**Holotype**, EAN 26.231).

ETYMOLOGY: Latin, *panthericolor*, referring to the brown conidia with multiple smoky or gray-brown spots, similar to the skin patterning of the leopard (*Panthera pardus*).

Fig. 1. *Beltraniomyces panthericolor* (holotype, EAN 26.231). A–D. Conidia; E. Conidiogenous cell and conidium; F. Conidiogenous cells and conidium; G. Conidiophore, conidiogenous cells, and conidia; H. Conidiophores in group, conidiogenous cells, and conidia. Scale bars: A–D = 10 µm; E = 20 µm; F–H = 40 µm.

Colonies scattered, dark brown. Mycelium superficial and immersed, composed of slightly branched, septate, smooth, pale brown to brown hyphae. Conidiophores macronematous, mononematous, erect, straight or flexuous, unbranched, geniculate, 5–25-septate, brown, smooth, 83–522

× 4–10 µm. Conidiogenous cells polyblastic, integrated, terminal and intercalary, brown to pale brown, with indeterminate, sympodial, percurrent extensions, ≤390 µm long. Conidial secession schizolytic. Conidia solitary, biconic, subulate to mucronate apex, cuneiform and truncate at the base, brown, with multiple, irregular, smoky to gray-brown spots covering the conidial body; median transversal band subhyaline, smooth, dry, 31–62(–45) × 15–22 µm.

Comments—*Beltraniomyces lignicola* is distinguished by smooth biconic conidia that are acute at the apex and truncate at the base, subhyaline to pale brown, with a hyaline median transverse band, 31–38.5 × 19–24 µm (Manoharachary & al. 2003). *Beltraniomyces panthericolor* is easily distinguished from *B. lignicola* by conidial shape, pigmentation, and size.

Beltraniomyces pulcher F.R. Barbosa, Fiuza, G.C.K. Barbosa, R.F. Castañeda & Gusmão, **sp. nov.** Fig. 2

MB 830314

Differs from *Beltraniomyces lignicola* by its rounded to subobtuse conidial apex.

Type: Brazil, Mato Grosso State, Cotriguaçú, 9°52′24″S 58°13′17″W, on decaying wood, 15.XII.2017, coll. G.C.K. Barbosa (**Holotype**, CNMTf 77).

Etymology: Latin, *pulcher*, meaning beautiful.

Colonies scattered, dark brown. Mycelium superficial and immersed, composed of slightly branched, septate, smooth, pale brown to brown hyphae. Conidiophores macronematous, mononematous, erect, straight or flexuous, unbranched, geniculate, 10–25-septate, brown, smooth, 450–750 × 6–12 µm. Conidiogenous cells polyblastic, integrated, terminal and intercalary, with indeterminate, sympodial, percurrent extensions, brown to pale brown, ≤300 µm long. Conidial secession schizolytic. Conidia solitary, biconic, rounded to subobtuse apex, truncate at the base, brown with a hyaline median transversal band, smooth, dry, 30–45 × 15–23 µm.

Additional specimens examined: **BRAZIL, Mato Grosso State**, Novo Mundo, 9°28′06″S 55°50′36″W, on decaying wood, 29.XI.2016, coll. G.C.K. Barbosa (CNMTf 78); 3.XII.2015, coll. G.C.K. Barbosa (CNMTf 79).

Comments—*Beltraniomyces pulcher* is separated from *B. lignicola* and *B. panthericolor* by its apically rounded or subobtuse conidia and larger conidiophores, with the conidia distinguished by acute apices in *B. lignicola* (Manoharachary & al. 2003) and subulate to mucronate in *B. panthericolor*. *Beltraniomyces pulcher* also lacks the distinctive leopard-like coloration found in *B. panthericolor*.

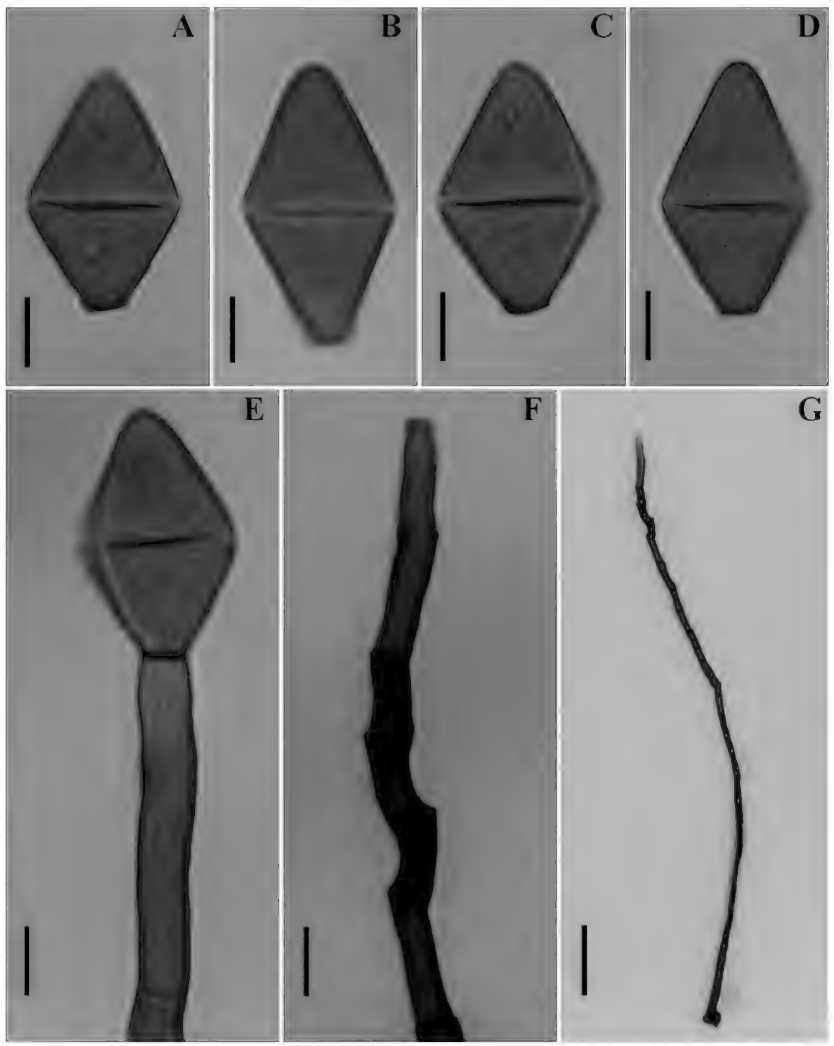

FIG. 2. *Beltraniomyces pulcher* (holotype, CNMTf 77). A–D. Conidia; E. Conidiogenous cell and conidium; F. Conidiogenous cells; G. Conidiophore. Scale bars: A–E = 10 μm; F = 25 μm; G = 90 μm.

Key to *Beltraniomyces* species

1. Conidia with multiple smoky or gray-brown spots, subulate to mucronate apex, cuneiform base ..... *B. panthericolor*
1. Conidia not as above 2
2. Conidia with acute apex, 31–38.5 × 19–24 μm ..... *B. lignicola*
2. Conidia with rounded to subobtuse apex, 30–45 × 15–23 μm ..... *B. pulcher*

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Coenogonium hainanense sp. nov. and new records from China

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Abstract—A new species, *Coenogonium hainanense*, is proposed, characterized by its small slightly transparent pale yellow to brownish apothecia with plane to concave discs; slightly thick, not prominent, denticulate margins with short dense hairs; and uniseriate or irregularly biseriate, ellipsoid 1-septate ascospores (10–11.25 × 2.5–3.75 µm). Eight additional *Coenogonium* species reported as new to China are *C. coronatum*, *C. curvulum*, *C. fallaciosum*, *C. geralense*, *C. hypophyllum*, *C. moniliforme*, *C. siquirrense*, and *C. usambarense*. Descriptions and distributions of the new species and records are presented, and a key to the 20 *Coenogonium* species known from China is provided.

Key words—*Coenogoniaceae, Lecanoromycetes,* lichens, *Ostropales,* taxonomy

Introduction

Coenogonium Ehrenb. (*Ostropales*: *Coenogoniaceae*), comprising more than 90 species worldwide, has a tropical and subtropical distribution and usually occurs on organic substrata, including bark, bryophytes, and leaves (Baloch & al. 2010, Ferraro & Michlig 2013, Joshi & al. 2015, Lücking & al. 2017, Kantvilas & al. 2018). The genus is characterized by a crustose or filamentous thallus with yellowish, orange, or brown biatorine apothecia and rounded, plane, or concave discs, usually distinct margins, a well-developed excipulum, simple paraphyses, narrowly cylindrical 8-spored asci with thin

Table 1. Distributions of *Coenogonium* species previously reported from China.

Species	Locality: reference
C. dilucidum	Guangxi & Hainan: Wu & al. 2018. Hong Kong: Aptroot & Seaward 1999, as *Dimerella dilucida*; Aptroot & Sipman 2001, as *D. dilucida*.
C. disjunctum	Taiwan: Wu & al. 2018.
C. interplexum	Taiwan: Wang-Yang 1972; Wang-Yang & Lai 1973; Wu & al. 2018. Yunnan: Wu & al. 2018.
C. isidiatum	Sichuan & Xizang: Obermayer 2004, as *D. isidiata*.
C. leprieurii	Fujian: Zahlbruckner 1930; Wu & al. 2018. Yunnan: Wu & al. 2018.
C. linkii	Guangxi & Hainan: Wu & al. 2018. Hong Kong: Aptroot & Seaward 1999; Seaward & Aptroot 2005, as *C.* cf. *linkii*; Pfister 1978, as *C. disjunctum*; Aptroot & Sipman 2001. Taiwan: Zahlbruckner 1933, as *C. subvirescens*; Asahina 1939, as *C. boninense*; Wang-Yang 1972; Wang-Yang & Lai 1973; Yoshimura 1974, as *C. boninense*; Wu 1987, as *C. boninense*.
C. luteum	Zhejiang: Wu & Qian 1989, *D. lutea*. Anhui: Wu & al. 2018. Fujian: Zahlbruckner 1930, as *Microphiale lutea*; Wu & al. 2018. Hubei: Chen & al. 1989, as *D. lutea*. Hainan: Wu & al. 2018. Hong Kong: Aptroot & Seaward 1999, as *D. lutea*; Seaward & Aptroot 2005, as *D. lutea*; Pfister 1978, as *Gyalecta lutea*; Aptroot & Sipman 2001, as *D. lutea*.
C. minimum	Guangxi: Wang & Wei 2018.
C. pineti	Hong Kong: Aptroot & Sipman 2001, as *D. pineti*. Taiwan: Aptroot & Sparrius 2003, as *D. pineti*.
C. subluteum	Hong Kong: Aptroot & Seaward 1999, as *D. epiphylla*; Aptroot & Sipman 2001, as *D. epiphylla*. Taiwan: Chung 1995, as *D. epiphylla*; Aptroot & al. 2003. Yunnan: Zahlbruckner 1930, as *M. brachyspora*, *M. epiphylla*, and *M. lutea* f. *foliicola*; Santesson 1952, as *D. epiphylla*; Wei & Jiang 1991; Aptroot & al. 2003; Wu & al. 2018.
C. zonatum	Yunnan: Aptroot & al. 2003.

walls and unthickened apices lacking internal amyloid structures; typically (0–)1-septate ellipsoid to fusiform hyaline ascospores; the absence of lichen secondary substances; and the presence of a trentepohliod photobiont (Lücking & Kalb 2000, Rivas Plata & al. 2006, Lücking 2008).

Eleven *Coenogonium* species have been reported from China: *C. dilucidum* (Kremp.) Kalb & Lücking, *C. disjunctum* Nyl., *C. interplexum* Nyl., *C. isidiatum* (G. Thor & Vězda) Lücking & al., *C. leprieurii* (Mont.) Nyl., *C. linkii* Ehrenb., *C. luteum* (Dicks.) Kalb & Lücking, *C. minimum* (Müll. Arg.) Lücking, *C. pineti* (Ach.) Lücking & Lumbsch, *C. subluteum* (Rehm) Kalb & Lücking, and *C. zonatum* (Müll. Arg.) Kalb & Lücking (Table 1). Our current research on *Coenogonium* revealed one new species and eight species records for China.

Materials & methods

The specimens are deposited in the Herbarium Mycologicum Academiae Sinicae-Lichenes, Beijing, China (HMAS-L), and the Fungarium, College of Life Sciences,

Liaocheng University, China (LCUF). An Olympus SZX16 dissecting microscope and Olympus BX53 light microscope were used for the morphological and anatomical studies. Measurements were taken from manual cross sections of fruit bodies in water. Amyloidity of the ascospores was tested using Lugol's solution. The thallus surface and thin thallus sections were spot tested with 20% KOH. The lichen substances were detected and identified by thin-layer chromatography (Culberson & Kristinsson 1970, Culberson 1972, White & James 1985, Jia & Wei 2016).

Taxonomy

Coenogonium hainanense X.H. Wu & Z.F. Jia, **sp. nov.** FIG. 1

FN 570605

Differs from *Coenogonium lisowskii* by its larger apothecia and ascospores.

TYPE: **CHINA. HAINAN PROVINCE, Changjiang County,** Bawang Ridge, 19°16′N 109°03′E, alt. 700 m, on leaves, 5 Sep. 2008, B. Gao HNF056 (**Holotype**, HMAS-L 126438).

ETYMOLOGY: The specific epithet refers to the type locality, Hainan Island.

THALLUS crustose, foliicolous, very thin, smooth, pale green to grey green, slightly shiny. APOTHECIA epiphyllous, sessile, rounded, 0.1–0.3 mm

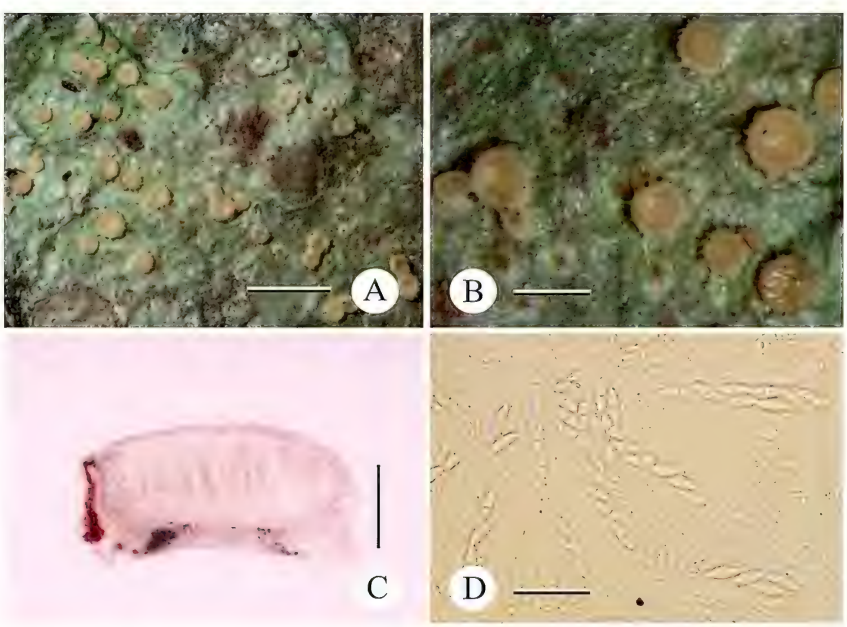

FIG. 1. *Coenogonium hainanense* (holotype, HMAS-L 126438). A. Thallus with apothecia; B. Apothecia; C. Cross section of apothecium; D. Ascus with ascospores. Scale bars: A = 1 mm; B = 0.5 mm; C = 100 μm; D = 20 μm.

diam.; disc plane to concave, pale yellow to brownish, slightly transparent; margin slightly thick, not prominent, denticulate, with short dense hairs of fungal hyphae, wax-colored; EXCIPLE colorless, 20–35 µm broad; HYMENIUM 60–70 µm high, colorless; HYPOTHECIUM 15–20 µm high, colorless to pale brownish. ASCI 8-spored, 50–70 × 7–9 µm; ASCOSPORES uniseriate or irregularly biseriate, ellipsoid, 1-septate, 10–11.25 × 2.5–3.75 µm, 3–4 times as long as broad. PYCNIDIA not observed.

CHEMISTRY: No lichen substances detected by TLC.

ECOLOGY & DISTRIBUTION: On the surface of living leaves in humid, semi-exposed forests of Hainan Island, south China.

REMARKS: *Coenogonium hainanense* is characterized by its small pale yellow to brownish, slightly transparent apothecia with plane to concave discs; slightly thick, not prominent, and denticulate margins covered by short dense hairs; ellipsoid ascospores, 1-septate, 10–11.25 × 2.5–3.75 µm. The new species is very similar to *C. lisowskii* (Vězda) Lücking and *C. dilucidum*, but *C. lisowskii* has smaller apothecia (0.05–0.15 mm diam.) with smooth hairless margins and smaller ascospores (7–9 × 1.8–2.5 µm), and *C. dilucidum* has broader ascospores (3.75–5 µm diam.; Lücking 2008).

Coenogonium coronatum G. Neuwirth & Stock.-Wörg., Bryologist 117: 161 (2014) FIG. 2

THALLUS crustose, foliicolous, smooth, yellowish green to pale green. APOTHECIA epiphyllous, sessile, rounded, 0.15–0.35 mm diam.; discs plane (concave in young apothecia), pale yellow to creamy; margins slightly thick, densely pilose, cream-colored, hairs consisting of fungal hyphae. ASCI 8-spored, 35–50 × 6–8 µm; ASCOSPORES irregularly biseriate, ellipsoid, 1-septate, 10–12.5 × 3–3.75 µm, 2.7–3.3 times as long as broad.

SPECIMEN EXAMINED: **CHINA. HAINAN PROVINCE, Ledong County**, Jianfeng Ridge, Mingfeng Valley, alt. 960 m, 6 Sep. 2017, W.C. Wang HN20170170 (HMAS-L 139527).

ECOLOGY & DISTRIBUTION: On leaves. South-East Asia: Thailand (Neuwirth & al. 2014, Kalb & al. 2016). New record for China.

REMARKS: *Coenogonium coronatum* is characterized by its small and pale-yellow apothecia with concave disc, and slightly thick, densely pilose margin. The species resembles *C. subluteum,* which differs in having cilia on the outer excipulum (Kalb & al. 2016).

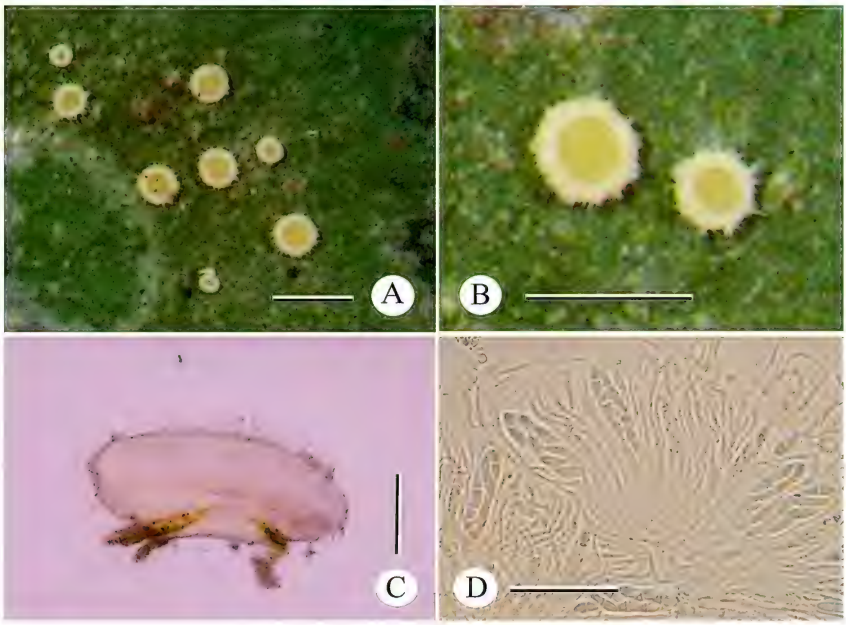

Fig. 2. *Coenogonium coronatum* (HMAS-L 139527). A. Thallus with apothecia; B. Apothecia; C. Cross section of apothecium; D. Ascus with ascospores; Scale bars: A, B = 0.5 mm; C = 100 µm; D = 50 µm.

Coenogonium curvulum Zahlbr., Ann. Cryptog. Exot. 1: 164 (1928) Fig. 3

Thallus filamentous, foliicolous, green to bright green, forming a thin crust of irregular filaments attached to the substrate from which a short and dense layer of erect filaments emerge. Apothecia sessile, rounded, 0.2–0.45 mm diam., immersed in a loose algal carpet, pale yellow to yellow; discs plane to slightly concave; margins glabrous, smooth, cream-colored. Asci 8-spored; ascospores curved, colorless, biseriate, ellipsoid, 1-septate, 6.25–7.5 × 2.5 µm, 2.5–3 times as long as broad.

Specimens examined: **CHINA. Hainan Province, Wuzhishan City**, Wuzhishan Tropical Rainforest Scenic Area, alt. 600 m, 9 Sep. 2017, W.C. Wang HN20170360 (HMAS-L 139783); Wuzhishan National Forest Park, alt. 800 m, 8 Sep. 2017, W.C. Wang HN20170335 (HMAS-L 139428); **Changjiang County**, Bawang Ridge, Baishitan, alt. 700 m, 9 Sep. 2017, W.C. Wang HN20170039 (HMAS-L 139418).

Ecology & distribution: On leaves. Neotropics and eastern Paleotropics: Indonesia (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium curvulum* is characterized by its filamentous, foliicolous thallus with short, upright hair-like algal threads and

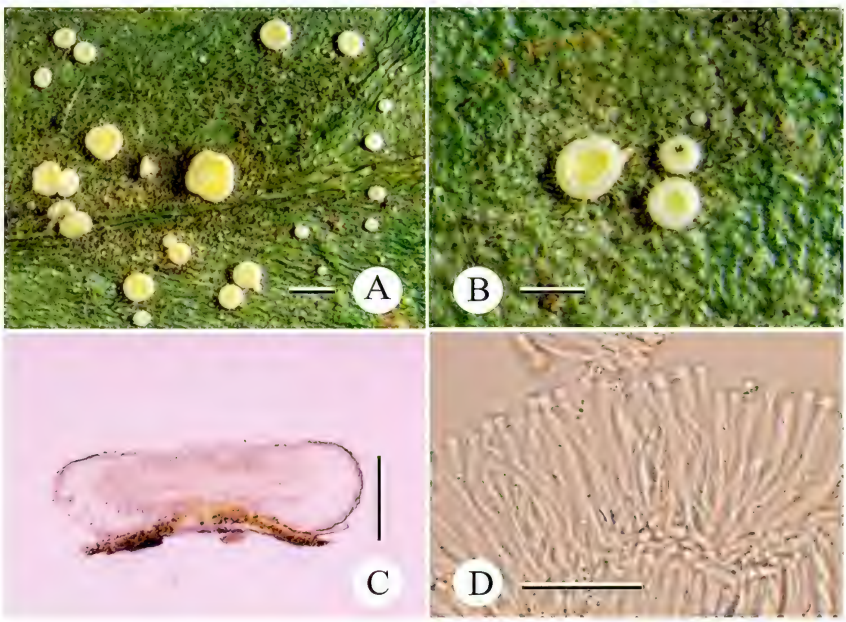

Fig. 3. *Coenogonium curvulum* (HMAS-L 139783). A. Thallus with apothecia; B. Apothecia; C. Cross section of apothecium; D. Ascus with ascospores. Scale bars: A, B = 0.5 mm; C = 100 µm; D = 50 µm.

curved ellipsoid ascospores. It resembles *C. epiphyllum* Vain., which is distinguished by larger (0.3–0.8 mm diam.) apothecia and straight ascospores.

Coenogonium fallaciosum (Müll. Arg.) Kalb & Lücking,
Bot. Jahrb. Syst. 122: 32 (2000) Fig. 4

Thallus crustose, foliicolous, pale green to grey green. Apothecia mostly marginally hypophyllous on mycelium-free algae, sessile, rounded, 0.3–1(–1.5) mm diam.; disc plane, pale yellow to yellow orange; margin very thin, smooth, concolorous with disc or slightly paler. Asci 8-spored; ascospores colorless, uniseriate or irregularly biseriate, ellipsoid, 1-septate, 7–10 × 2.5–3.5 µm, 2.5–3.5 times as long as broad.

Specimens examined: **CHINA. Hainan Province, Changjiang County**, Bawang Ridge, Baishitan, alt. 700 m, 4 Sep. 2017, W.C. Wang HN20170026 (HMAS-L 139458), HN20170031 (HMAS-L 139463), HN20170036 (HMAS-L 139468), HN20170038 (HMAS-L 139470), HN20170042 (HMAS-L 139473); **Baoting County**, Qixian Ridge National Forest Park, alt. 350 m, 7 Sep. 2017, W.C. Wang HN20170239 (HMAS-L 139553), HN20170274 (HMAS-L 139494), HN20170275 (HMAS-L 139495), HN20170276 (HMAS-L 139496), HN20170277 (HMAS-L 139497), S.H. Jiang

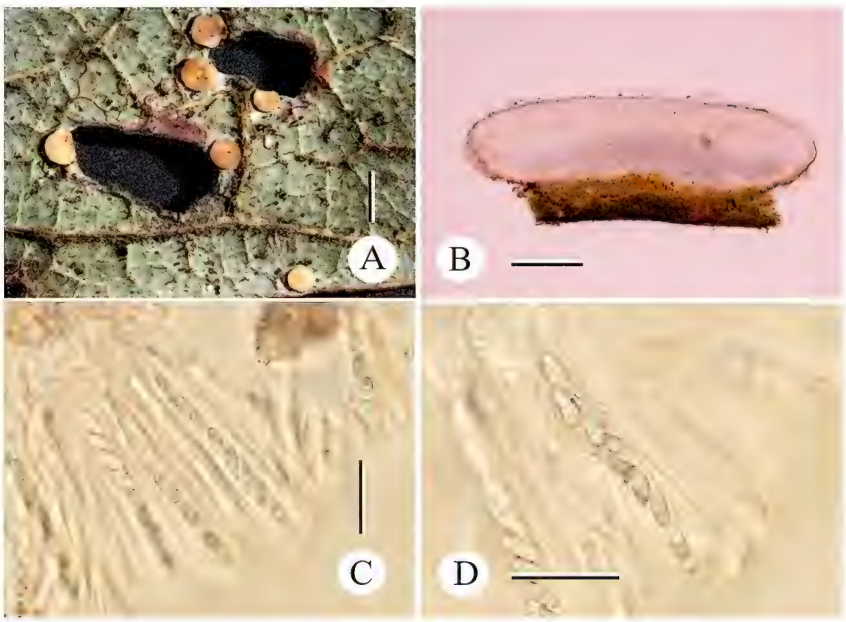

Fig. 4. *Coenogonium fallaciosum* (HMAS-L 139775). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascospores uniseriate D. Ascospores irregularly biseriate. Scale bars : A = 2 mm; B = 100 μm; C, D = 20 μm.

HN20171262 (HMAS-L 144212); **Wuzhishan City**, Wuzhishan National Forest Park, alt. 800 m, 8 Sep. 2017, W.C. Wang HN20170328 (HMAS-L 139770), HN20170333 (HMAS-L 139775); **Yunnan Province**, **Xishuangbanna**, Mengla County, Tropical Botanical Garden of Chinese Academy of Sciences, alt. 529 m, 25 Jan 2018, W.C. Wang 20180225 (HMAS-L 144228).

Ecology & distribution: On leaves. Pantropical: Brazil (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium fallaciosum* is characterized by its apothecia mostly marginally hypophyllous on mycelium-free algae and very thin, smooth margins. It resembles *C. geralense,* which differs in smaller apothecia (0.4–1 mm diam.), smaller ascospores (6.25–8.75 × 1.8–2.5 μm), and pale yellow to bright yellow (never orange) apothecia (Lücking 2008).

Coenogonium geralense (Henn.) Lücking,
Fl. Neotrop., Monogr. 103: 579 (2008) Fig. 5

Thallus crustose, foliicolous, thin, yellowish green to grey green. Apothecia epiphyllous or marginally hypophyllous, sessile, rounded,

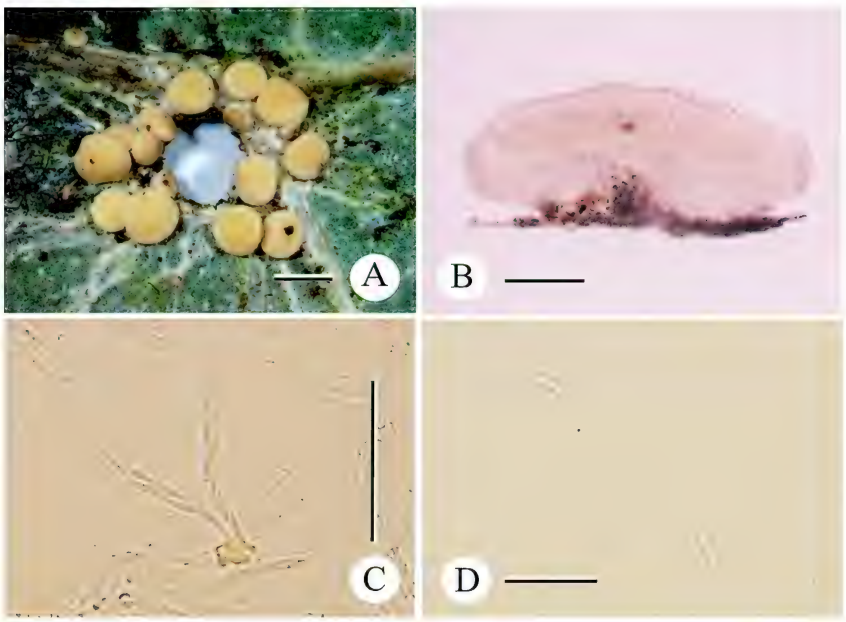

Fig. 5. *Coenogonium geralense* (HMAS-L 144268). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus with ascospores; D. Ascospores. Scale bars: A = 1 mm; B = 100 µm; C = 50 µm; D = 20 µm.

0.4–1 mm diam.; disc plane to concave, pale to bright yellow; margins thin, smooth, concolorous to disc or paler. Asci 8-spored, 45–55 × 6–7 µm; ascospores uniseriate or irregularly biseriate, narrowly ellipsoid, 1-septate, 6.25–8.75 × 1.8–2.5 µm, 3–4 times as long as broad.

Specimens examined: **CHINA. Hainan Province, Qiongzhong,** Mt. Limu, alt. 800 m, 18 Dec. 2000, M.R. Huang 458 (HMAS-L 108841); **Lingshui County**, Mt. Diaoluo, alt. 1050 m, 14 Sep. 2000, M.R. Huang 337 (HMAS-L 112801); **Ledong County**, Jianfeng Ridge, Mingfeng Valley, alt. 960 m, 6 Sep. 2017, W.C. Wang HN20170168 (HMAS-L 139525), HN20170169 (HMAS-L 139526), HN20170171 (HMAS-L 139434); **Yunnan Province, Mengla County**, Tropical Botanical Garden of Chinese Academy of Sciences, Greenstone Forest Scenic Area, 614 m alt., 26 Jan. 2018, W.C. Wang 20180236 (HMAS-L 144268).

Ecology & distribution: On leaves. Pantropical: Brazil (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium geralense* is characterized by its crustose, foliicolous, smooth, yellowish green to grey green thallus and ellipsoid,

1-septate ascospores. It is similar to *C. dilucidum*, which is distinguished by larger ascospores (6–12 × 2.5–3.5 µm; Kalb & al. 2016).

Coenogonium hypophyllum (Vězda) Kalb & Lücking,
Bot. Jahrb. Syst. 122: 32 (2000) Fig. 6

Thallus crustose, foliicolous, hypophyllous, thin, smooth, pale greenish grey to yellow brownish. Apothecia hypophyllous, sessile, rounded, 0.25–0.35 mm diam.; discs plane to concave, pale yellow; margins thin, smooth to minutely dentate, wax-colored. Asci 8-spored, 45–60 × 6–8 µm; ascospores irregularly biseriate, fusiform, 1-septate, 11.25–15 × 2.5 µm, 5–6 times as long as broad.

Specimen examined: **CHINA. Hainan Province, Ledong County**, Jianfeng Ridge, alt. 900 m, 3 Apr. 1993, Y.M. Jiang & S.Y. Guo H-0695 (HMAS-L 138640).

Ecology & distribution: On leaves. Pantropical: Tanzania (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium hypophyllum* is characterized by its foliicolous thallus and regularly hypophyllous apothecia with smooth to minutely

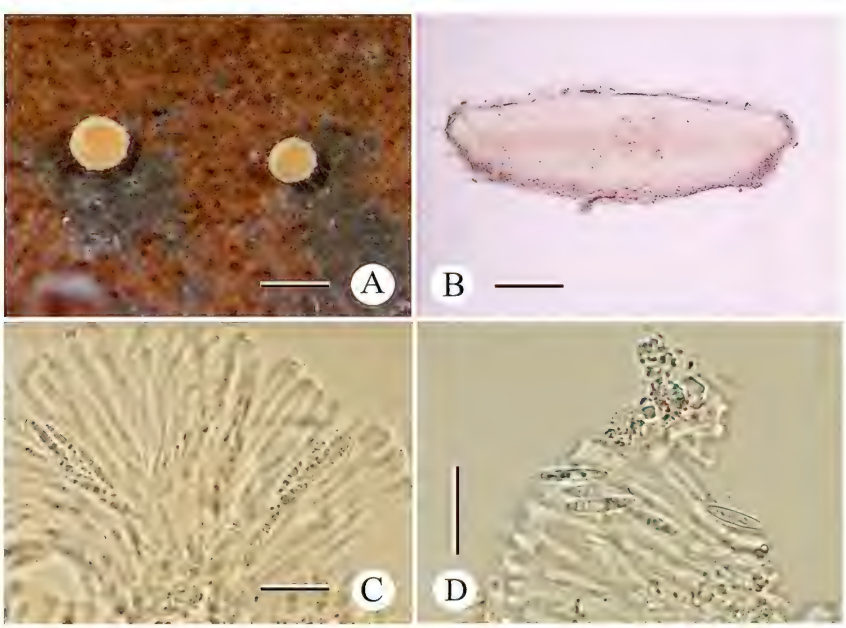

Fig. 6. *Coenogonium hypophyllum* (HMAS-L 138640). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus with ascospores; D. Ascospores. Scale bars: A = 0.5 mm; B = 100 µm; C, D = 20 µm.

dentate margins. It resembles *C. subzonatum* (Lücking) Lücking & Kalb, which differs in its apothecia marginally hypophyllous on a mycelium free of algae and smaller ascospores (7–10 × 2.5–3.5 µm; Lücking 2008).

Coenogonium moniliforme Tuck., Proc. Amer. Acad. Arts 5: 416 (1862) Fig. 7

Thallus filamentous with densely woven filaments forming closely appressed mats, moderately thick, pale to dark green or brownish green. Apothecia sessile, rounded, 0.2–0.35 mm diam.; discs plane to concave, pale to dark orange; margins thin, smooth, wax-colored. Asci 8-spored, 45–55 × 6–8 µm; ascospores irregularly biseriate, fusiform, 1-septate, 8.75–11.25 × 2.5–3.75 µm, 2.3–4.5 times as long as broad.

Specimens examined: **CHINA. Hainan Province, Ledong County**, Jianfeng Ridge, Mingfeng Valley, alt. 960 m, 6 Sep. 2017, W.C. Wang HN20170218 (HMAS-L 139421), S.H. Jiang HN20171048 (HMAS-L 144213).

Ecology & distribution: On leaves. Pantropical: Cuba (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium moniliforme* is characterized by its filamentous thallus with the densely woven filaments forming closely appressed mats and plane to

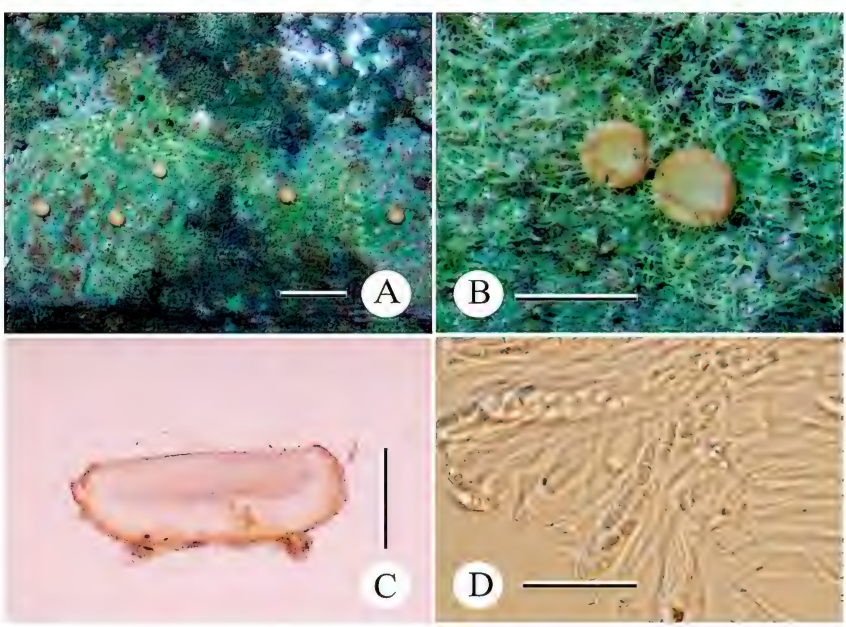

Fig. 7. *Coenogonium moniliforme* (HMAS-L 144213). A. Thallus with apothecia; B. Apothecia; C. Cross section of apothecium; D. Ascus with ascospores. Scale bars: A = 1 mm; B = 0.5 mm; C = 100 µm; D = 30 µm.

concave, pale to dark orange discs. It closely resembles *C. flavoviride* M. Cáceres & Lücking, which is distinguished by its much smaller ascospores (4–6 × 1.8–2 µm; Lücking 2008).

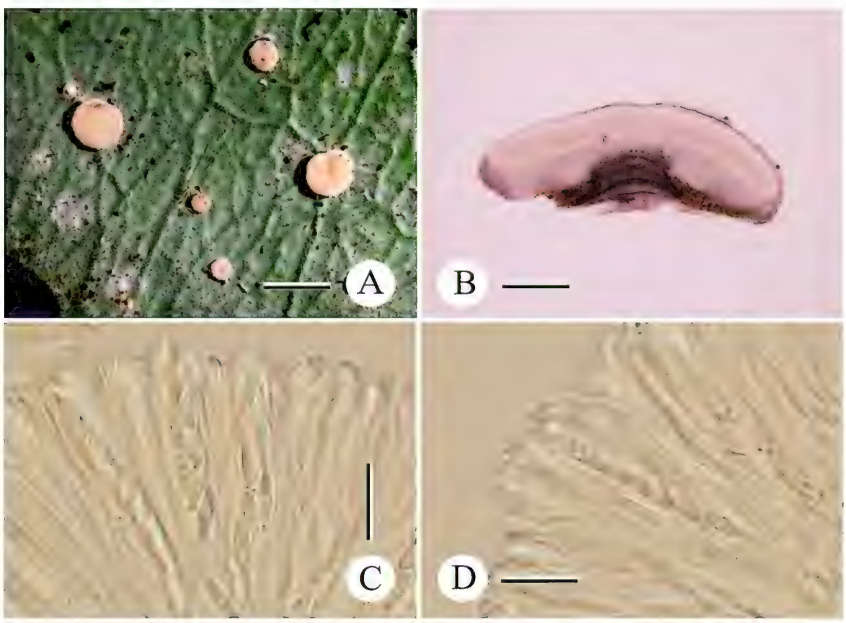

Fig. 8. *Coenogonium siquirrense* (HMAS-L 139552). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascospores irregularly biseriate; D. Ascospores uniseriate. Scale bars: A = 1 mm; B = 100 µm; C, D = 20 µm.

Coenogonium siquirrense (Lücking) Lücking,
Fl. Neotrop., Monogr. 103: 580 (2008) Fig. 8

Thallus crustose, foliicolous, continuous, thin, smooth, green to dark green. Apothecia mostly epiphyllous, sessile, rounded, 0.5–0.8 mm diam.; discs plane, orange with darker marginal zone and paler centre; margins thin, smooth, pale orange. Asci 8-spored, 30–45 × 3–4 µm; ascospores uniseriate or irregularly biseriate, narrowly ellipsoid, 1-septate, 7.5–10 × 2–2.5 µm, 3–4 times as long as broad.

Specimen examined: **CHINA. Hainan Province, Baoting County**, Qixian Ridge National Forest Park, 350 m alt., 7 Sep. 2017, W.C. Wang HN20170238 (HMAS-L 139552).

Ecology & distribution: On leaves. Neotropics: Costa Rica (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium siquirrense* is characterized by its crustose, foliicolous thallus, mostly epiphyllous sessile 0.5–0.8 mm diam. apothecia, and narrowly ellipsoid ascospores. The closely similar *C. geralense* differs in its pale to bright yellow often marginally hypophyllous apothecia with plane to concave discs (Lücking 2008). The also similar *C. luteum* is distinguished by its larger (0.5–2 mm diam.), more prominent apothecia and broader ascospores (2.5–3.75 µm diam.; Lücking 2008).

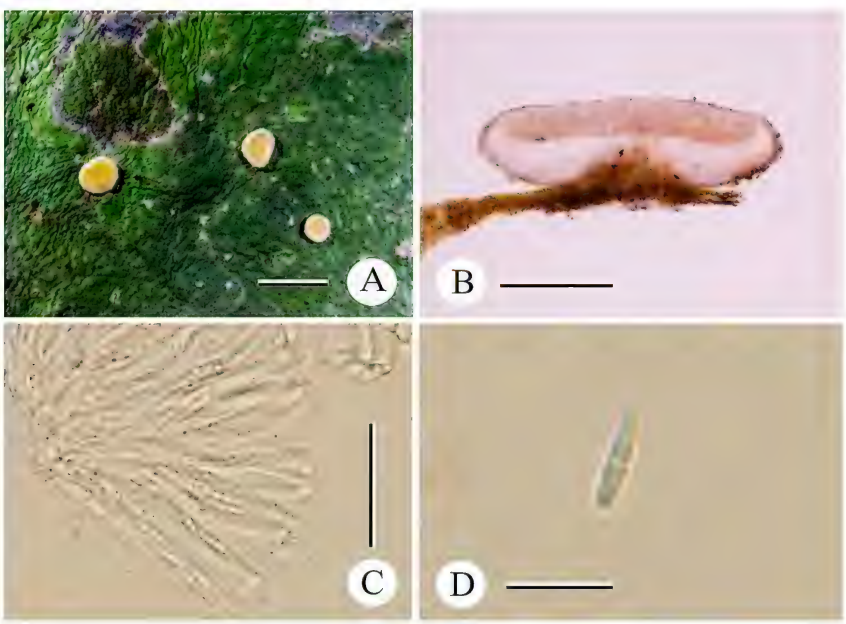

Fig. 9. *Coenogonium usambarense* (HMAS-L 139777). A. Thallus with apothecia; B. Cross section of apothecium; C. Ascus with ascospores; D. Ascospores. Scale bars: A = 2 mm; B = 200 µm; C = 50 µm, D = 10 µm.

Coenogonium usambarense (Vězda & Farkas) Lücking & Kalb, Biblioth. Lichenol. 78: 255 (2001) Fig. 9

Thallus crustose, foliicolous, epiphyllous, thin, smooth, green to bright green. Apothecia sessile, rounded, 0.4–0.8 mm diam.; discs plane to slightly convex, pale yellow to orange; margins smooth, cream-colored. Asci 8-spored, 40–45 × 4–6 µm; ascospores irregularly biseriate, ellipsoid, 1-septate, 8.5–11.25 × 2.5–3 µm, 4–5 times long as broad.

Specimens examined: **China. Hainan Province, Wuzhishan City**, Wuzhishan National Forest Park, 800 m alt., 8 Sep. 2017, W.C. Wang HN20170336 (HMAS-L

139777); **Yunnan Province, Mengla County**, Tropical Botanical Garden of Chinese Academy of Sciences, 549 m alt., 25 Jan. 2018, X.H. Wu YN18082 (LCU); Greenstone Forest Scenic Area, Dabangen, 672 m alt., 26 Jan. 2018, X.H. Wu YN18160 (LCU).

Ecology & distribution: On leaves. African and eastern Paleotropics: Tanzania (Rivas Plata & al. 2006). New record for China.

Remarks: *Coenogonium usambarense* is characterized by a crustose, foliicolous, epiphyllous, thin, smooth, and green or bright green thallus and ellipsoid ascospores (8.5–11.25 × 2.5–3 μm). The similar *C. epiphyllum* produces much shorter and broader ascospores (6–8 × 2.5–3.75 μm; Vězda & Farkas 1988).

Key to all the known species of *Coenogonium* in China

1. Thallus filamentous 2
1. Thallus crustose 7
2. Thallus distinctly filamentous, in loose, erect mats or horizontally projecting, shelf-like structures 3
2. Thallus indistinctly filamentous, in thin densely woven mats or with well-developed upright short filaments 6
3. Ascospores simple, 5–8 × 2–3 μm ..... *C. leprieurii*
3. Ascospores 1-septate 4
4. Thallus dimidiate or shelf-like; ascospores 6–9 × 2–3 μm ..... *C. linkii*
4. Thallus prostrate, irregularly woven 5
5. Ascospores 7–10 × 2–3 μm ..... *C. interplexum*
5. Ascospores 10–14 × 2.5 μm ..... *C. disjunctum*
6. Ascospores 8.75–11.25 × 2.5–3.75 μm ..... *C. moniliforme*
6. Ascospores 6.75–7.5 × 2.5 μm ..... *C. curvulum*
7. Thallus with isidia; ascospores 9–14 × 3–4 μm ..... *C. isidiatum*
7. Thallus lacking isidia 8
8. Thallus and apothecia regularly hypophyllous; ascospores 11.25–15 × 2.5 μm, fusiform ..... *C. hypophyllum*
8. Thallus and apothecia epiphyllous or apothecia often marginally hypophyllous ... 9
9. Apothecia very small, 0.1–0.25 mm 10
9. Apothecia larger, 0.25–2 mm 11
10. Apothecia light brown to yellow brown with strongly concave discs and thick margins; ascospores 10–14 × 3–4 μm ..... *C. minimum*
10. Apothecia wax-colored to pale yellow with flat to slightly concave discs; ascospores 10–12.5 × 3.75–5 μm ..... *C. dilucidum*
11. Apothecia margin densely pilose or slightly denticulate 12
11. Apothecia margin smooth 13

12. Apothecia pale yellow to creamy, margins cream-colored, densely pilose (sometimes abraded in older apothecia); ascospores 10–12.5 × 3–3.75 µm ..... *C. coronatum*
12. Apothecia pale yellow to brownish, slightly transparent, margins denticulate; ascospores 10–11.25 × 2.5–3.75 µm ..... *C. hainanense*
13. Ascospores narrowly ellipsoid to oblong (1.8–2.5 µm broad), usually irregularly biseriate 14
13. Ascospores broadly ellipsoid (2.5–5 µm broad), usually uniseriate 15
14. Apothecia pale to bright yellow with pale margins; ascospores 6.25–8.75 × 1.8–2.5 µm ..... *C. geralense*
14. Apothecia orange with darker marginal zones and paler centres; ascospores 7.5–10 × 2–2.5 µm ..... *C. siquirrense*
15. Apothecia 1–2 mm, bright yellow to yellow orange; ascospores 7.5–8.75 × 2.5–3.75 µm ..... *C. luteum*
15. Apothecia 0.25–1 mm, wax-colored to pale orange 16
16. Apothecia usually marginally hypophyllous, 0.3–1(–1.5) mm, pale yellow to yellow orange; margins very thin, smooth, concolorous with disc or slightly paler; ascospores 7–10 × 2.5–3.5 µm ..... *C. fallaciosum*
16. Apothecia usually epiphyllous 17
17. Apothecia wax-colored to pale orange 18
17. Apothecia white to pale yellow or orange 19
18. Prothallus present, white; ascospores 7.5–10 × 2.5–4 µm ..... *C. zonatum*
18. Prothallus absent; ascospores 10–12.5 × 2.5–3.75 µm ..... *C. subluteum*
19. Apothecia white to pinkish (rarely orange tinged), 0.2–0.5 mm, margins smooth; ascospores 9–14 × 2.3–4.5 µm ..... *C. pineti*
19. Apothecia pale yellow to orange, margins smooth, cream-colored; ascospores 8.5–11.25 × 2.5–3 µm ..... *C. usambarense*

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Cystostereum sirmaurense sp. nov. from India

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Abstract—A new corticioid species, *Cystostereum sirmaurense*, is described from Himachal Pradesh, India.

Key words—*Agaricales, Agaricomycetes, Basidiomycota, Cystostereaceae,* Himalaya

Introduction

During the fungal forays conducted in August 2015 in the Nahan area of district Sirmaur, Himachal Pradesh, India, Ramandeep & Avneet collected a corticioid specimen growing in association with a living angiospermous tree in a mixed forest. Based on its macro and micromorphological details and comparison with the literature (Rattan 1977, Eriksson & Ryvarden 1975, Bernicchia & Gorjón 2010, Prasher & Ashok 2013, Dhingra & al. 2014, Sanyal 2014, Mycobank 2019) it has been placed in *Cystostereum* Pouzar (*Cystostereaceae*), close to the type species *C. murrayi* (Berk. & M.A. Curtis) Pouzar. A portion of the basidiocarp was sent for expert comment to Prof. Nils Hallenberg (University of Gothenburg, Sweden), who confirmed the findings and supported the proposal of a new species, described here as *Cystostereum sirmaurense*.

Materials & methods

The collection was sampled during a field trip conducted in the Nahan forest division of the Sirmaur district (Himachal Pradesh, India) during August 2015. Colour standards follow Kornerup & Wanscher (1978). The dried specimen was deposited at the Herbarium, Department of Botany, Punjabi University, Patiala, India (PUN).

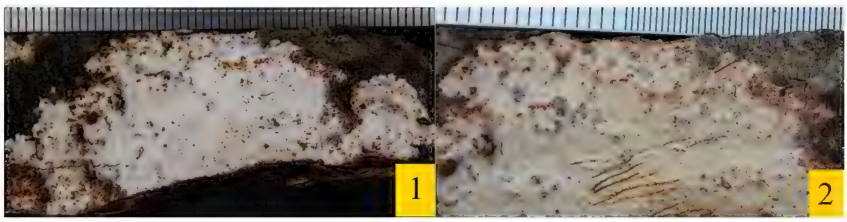

Plate 1. *Cystostereum sirmaurense* (holotype, PUN (Kaur 10097)). 1. Basidiocarp showing hymenial surface (fresh); 2. Basidiocarp showing hymenial surface (dry). Scales in mm.

Crush mounts and free hand sections were used to study the morphology of hyphae, cystidia, basidia, basidiospores, etc. in water and 3%, 5%, and 10% KOH solutions, and stained in cotton blue (1% in lactophenol), Congo red (1% in distilled water), phloxine (1% in distilled water), sulphovanillin (0.5gm vanillin + 4.0ml conc. sulphuric acid + 2.0ml distilled water), and Melzer's reagent (0.5gm iodine + 1.5gm KI + 20gm chloral hydrate + 20ml distilled water). Line diagrams of various microscopic structures were drawn using a camera lucida.

Taxonomy

Cystostereum sirmaurense R. Kaur, Avn.P. Singh & Dhingra, MB 829964 Plates 1,2

Differs from *Cystostereum murrayi* by its almost smooth hymenium with few scattered tubercles and more broadly ellipsoid basidiospores.

Type: India, Himachal Pradesh: Sirmaur, Nahan, 2 km from Ambwala towards Nahan, on a living angiospermous tree, 23 August 2015, Ramandeep Kaur & Avneet Pal Singh 10097 (, PUN).

Etymology: The epithet refers to the district where the collection was made.

Basidiocarp resupinate, effused, adnate, ≤340 µm thick in section; hymenial surface smooth but with minute scattered tubercles, white when fresh, becoming yellowish white to orange white on drying; margins thinning or indeterminate, paler concolorous. Hyphal system dimitic. Generative hyphae branched, with clamps, thin-walled, subhyaline up to 2.8 µm wide. Skeletal hyphae unbranched, aseptate, thick-walled, subhyaline up to 5.2 µm diam. Cystidia 26–44 × 7–8.5 µm, variably shaped but generally with an obtuse apex, thin- to somewhat thick-walled, with basal clamp, embedded in the hymenium and subhymenium, not staining in sulphovanillin. Basidia 15–20 × 3.8–4.7 µm, subclavate to clavate, 4-sterigmate, with basal clamps; sterigmata ≤3.3 µm long. Basidiospores 3.3–4.2 × 2.3–3.3 µm, ellipsoid to broadly ellipsoid, apiculate, thin-walled, smooth, inamyloid, acyanophilous.

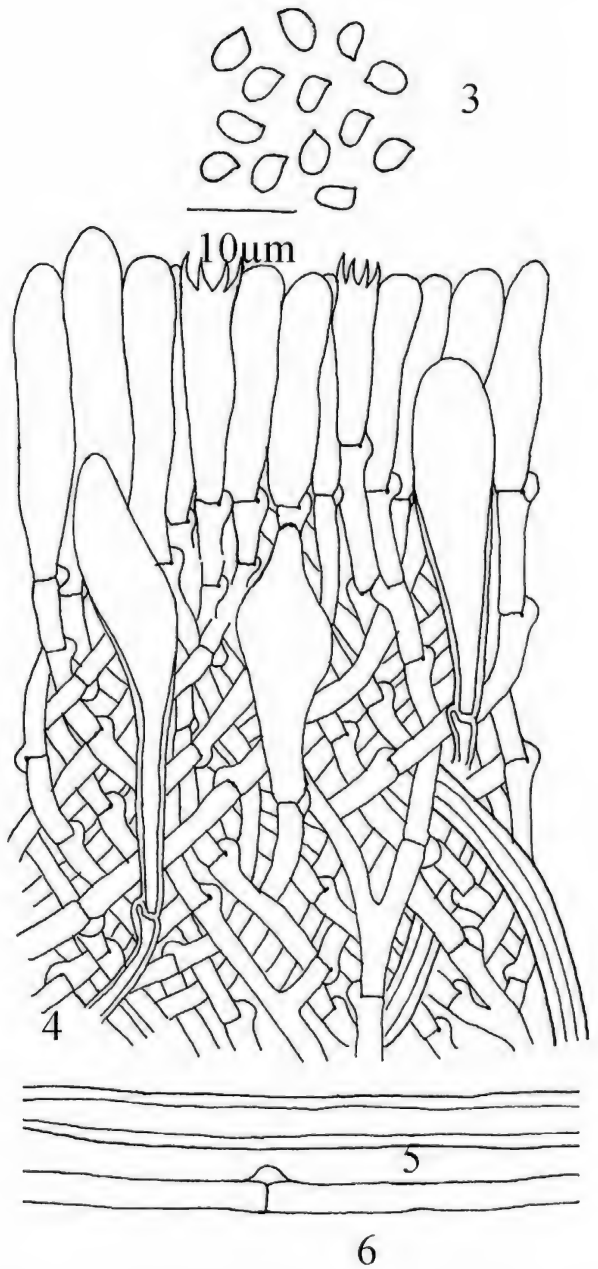

Plate 2. *Cystostereum sirmaurense* (holotype, PUN (Kaur 10097)). 3. Basidiospores; 4. Reconstruction of hymenial and subhymenial zones; 5. Skeletal hypha; 6. Generative hypha.

Discussion

Pouzar (1959) proposed *Cystostereum* on the basis of unique combination of numerous gloeocystidia, dimitic hyphal system with very scarce light-couriered skeletal hyphae, hard consistency of trama, and inamyloid basidiospores. With the addition of *C. sirmaurense*, eight species are now represented in *Cystostereum* (MycoBank 2019). From India, previously only *C. murrayi* has been described, from Himachal Pradesh (Rattan 1977; Kaur 2018) and Uttarakhand (Sanyal 2014). *Cystostereum murrayi* differs from *C. sirmaurense* in having a tuberculate hymenial surface and narrower basidiospores.

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The authors thank Head (Department of Botany, Punjabi University, Patiala) for providing research facilities, Dr. Nils Hallenberg (Professor Emeritus in Botany, University of Gothenberg) for expert comments and peer review, Prof. B.M. Sharma (Department of Plant Pathology, COA, CSKHPAU, Palampur, India) for peer review, and University Grants Commission (New Delhi, India) for financial assistance under DSA-I scheme.

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Regional annotated mycobiota new to the Mycotaxon website

Abstract—Mycotaxon is pleased to add a new annotated species distribution list to our 133 previously posted free-access fungae. The 9-page "Diversity of macrofungi in Yushan, Jiangsu, China" by Bing Xu, Haoyu Lu, Donglei Zhao, Wei Wang, and Hong Ji may be downloaded from our website via http://www.mycotaxon.com/mycobiota/index.html

ASIA

China

Bing Xu, Haoyu Lu, Donglei Zhao, Wei Wang, Hong Ji. Diversity of macrofungi in Yushan, Jiangsu, China. 9 p.

Abstract—A checklist is presented of 84 taxa of macrofungi collected from Yushan National Forest Park, Changshu city, Jiangsu province, China. The taxa represent 48 genera and 28 families, with taxa in *Russulaceae*, *Agaricaceae*, *Amanitaceae*, *Inocybaceae*, and *Psathyrellaceae* comprising 48.8% of the total collected. The food and medicinal potentials of the taxa are indicated.

Key Words—*Ascomycota, Basidiomycota,* natural resources

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Book reviews and notices*

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Abstract—Books reviewed include: An introduction to the edible, poisonous and medicinal fungi of northern Laos by Læssøe, Sparre Pedersen, and Sysouphanthong (2019), Mushrooms of the Gulf Coast States (A field guide to Texas, Louisiana, Mississippi, Alabama, and Florida) by Bessette, Bessette, and Lewis (2019), and Fungi of temperate Europe (volumes 1 & 2) by Læssøe & Petersen (2019).

An introduction to the edible, poisonous and medicinal fungi of northern Laos. By T. Læssøe, O. Sparre Pedersen, Ph. Sysouphanthong, 2019. Svampetryk, Kornblomsvej 6, 8381 Tilst, Denmark; svampetryk@svampe.dk 192p. 330 photos. This is an open-access publication, distributed under the terms of the Creative Commons Attribution Licence, which permits unrestricted use, distribution, and reproduction in any medium, provided it is for non-commercial purpose and the original source and the three authors are credited. It does not have an ISBN number.

ບາງສະໜິເຖິງ
ເຫັດທີ່ກິນໄດ້, ເປັນພິດ ແລະ ເປັນຢາ
ໃນພາກເໜືອ ສປປ ລາວ
An Introduction to the
Edible, Poisonous and Medicinal
Fungi of Northern Laos
Thomas Læssøe, Ole Sparre Pedersen and Phongeun Sysouphanthong

This book is one result from a Darwin Initiative grant to the James Hutton Institute (UK) for the purpose of "building mycological capacity

* Book reviews or books for consideration for coverage in this column should be sent to the Editor-in-Chief <editor@mycotaxon.com> 6720 NW Skyline, Portland OR 97229 USA.

for sustainable resource management in Lao PDR." Training of Laotian students in a laboratory was also part of this project.

This 'introduction' provides an overview of macrofungi from Xieng Khouang province in northern Laos. The focus is on those fungi that are considered either beneficial (edible or medicinal) or poisonous for people, and all text is in both English and Laotian.

The vegetation and mycoflora of Xieng Khouang province resemble those of northern Thailand, Yunnan province in China, and Japan—all three regions where mycology has seen a huge outpouring of publications on macrofungi in the last 15 years.

The book starts with a brief introduction to mushrooms, the different nutritional modes of fungi (including a paragraph on termite fungi), a page on classification and morphology, and another page addressing the various adverse reactions to and toxins of the poisonous fungi.

The fungi are organized systematically within the edible, potentially edible, poisonous, potentially poisonous, and medicinal categories, with *Microporus xanthopus* as the only representative of a fungus that is used for decoration.

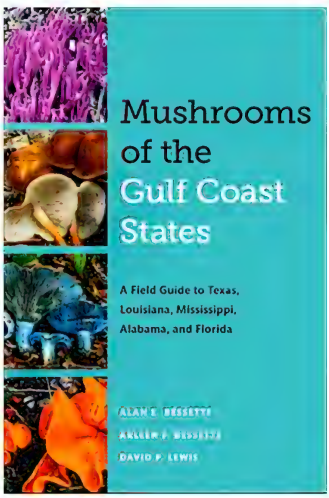
Each species gets its own page, with one to several excellent photos, a description, and notes on use in Laos. All photos, with the exception of two species, were taken in Laos—this type of information is very welcome.

Many species are identified as 'close to X' or 'resembling Y,' as Southeast Asia is still extraordinarily rich in undescribed fungal species, and the identification of the Laotian species was based solely on morphology.

An extensive reference list and an index complete the book.

This is the first book I know of that deals with Laotian fungi. In any case, information on the mycoflora of Laos is exceedingly rare. As in neighbouring countries, wild mushrooms form a huge part of the local diet and are a source of income as well; some species (for instance several species of red russulas) are dried and exported.

I like the cautious approach to the naming, and the efforts to link the local Laotian names to a scientific name. As I have been mushrooming in northern Thailand and Yunnan province, this book evokes happy memories of the forests and the visits to the markets and roadside mushroom sellers.



Mushrooms of the Gulf Coast States. A field guide to Texas, Louisiana, Mississippi, Alabama, and Florida. By A.E. Bessette, A.R. Bessette, and D.P. Lewis, 2019. University of Texas Press, utpress.utexas.edu https://doi,.org/10.7560/318157 ISBN 978-1-4773-1815-7. 614 pp, 667 colour photos, $ 39.95 Paperback [also available as an e-book].

It is always exciting to open a mushroom field guide for a region one does not know. And indeed, the mycoflora of the Gulf Coast states of the USA is quite different from that of California where I live.

This guide provides a description and photo for around 650 species, each species on its own page. The species are organized by group, and alphabetically within each group. The same artificial categories are used as in the earlier field guide for the southeastern USA (Bessette et al. 2007), which works well for a field guide. The alphabetical approach within a group, however, means that species that look alike and/or are closely related do not end up together.

A short introduction to the geographical area, the lifestyle of mushrooms, collecting methods, how to use the book, and pictorial keys to the main groups precede the descriptions and illustrations. The same type of photos as those serving to illustrate the species is used in the keys, but printed very small. Appendices at the back of the book provide information on microscopy and the chemicals used for identification, and there is a chapter devoted to mushrooms for the table. A glossary, a short of list of references and resources, and indices to common and scientific names complete the volume.

As noted, the bulk of the book is dedicated to the illustration and description of the mushroom species. The emphasis is on the more conspicuous species, so that only one *Inocybe* species is included and the two *Psathyrella* species feature only in the picture keys, but don't get their own page. Unfortunately, the introduction does not state how the descriptions were made: are they based on observations of the authors on material from the Gulf Coast states? Or, are they based on the literature?

There is a list of photographers, but there is no information whether the photographed material has been preserved in a herbarium or where the photos were taken. Unfortunately, many photos are too dark.

Some names that are used have not been officially published, such as "*Amanita amerifulva*" for the North American relative of the European *A. fulva*; in other cases, a European name is used, even when it is clear that the American species is different (e.g., *Macrolepiota procera* does not occur in North America, but the North American species have not yet been described). Only in a few cases are such taxonomic issues indicated by adding 'group' or 'complex' to a name; in my opinion this should have been done in many more cases. *Pluteus cervinus* is one such a case where more than one species occurs in the area. Synonyms are given for a number of species, but not for all, so one wonders how that selection was made; why is *Agaricus alboviolaceus* listed, but not *Agaricus conigenoides*? Some identification mistakes are obvious—the photo of *Tremella mesenterica* shows *T. aurantia* with *Stereum*. *Tremella mesenterica* parasitizes *Peniophora* species, and *Dacrymyces chrysospermus* (compared in the remarks to the *Tremella*), growing on conifer wood, is a wood decayer, not a fungal parasite. The photo of *Pluteus atromarginatus* shows a different species, and the text and the photo of *Mycena epipterygia* var. *viscosa* do not match, as the photo shows pruinose stipes, and the text calls the stipe 'smooth'.

One element that I sorely miss is a description of the main types of habitat the species were found in. What do these forests look like? Where are they? When and where to go if one would like to see these mushrooms with one's own eyes? Which species are really rare, and are there conservation plans for them or their habitats?

Also, the volume is probably too heavy to carry around in a backpack.

These problems aside, the book gives a wealth of information on southeastern North American species and will form a basis for much more in-depth work.

Bessette AE, Roody WC, Bessette AR, Dunaway DL. 2007. Mushrooms of the southeastern United States. Syracuse University Press.

Fungi of temperate Europe (volumes 1 & 2). T. Læssøe, J.H. Petersen. 2019. Princeton University Press. https://press.princeton.edu/titles/13983.html $110.00. ISBN 978-0-691-18037-3. 1708p. 7 1/2 x 11 1/2 inches, 7,000 color illus.

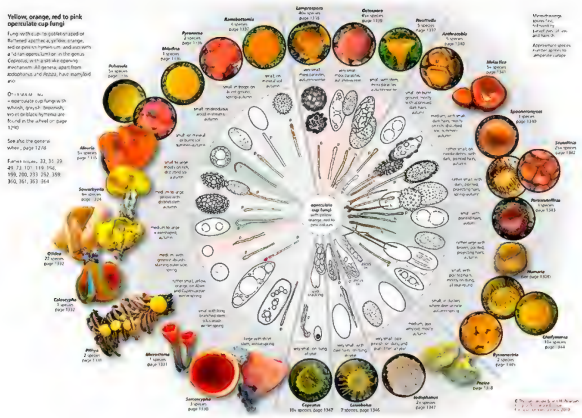
This translation of the Danish NORDEUROPAS SVAMPE gives descriptions and illustrations of around 2800 species of fungi occurring in northern temperate Europe.

This is not your standard guidebook. The whole book is extremely well thought out, with ease of identification as the most important criterion for lay-out and presentation. And that alone makes it worth buying.

The two authors are extremely experienced broadly interested field mycologists, educators, excellent photographers, and Jens Petersen has proven his skills in presenting data in the general mycology/coffee table book THE KINGDOM OF FUNGI (Petersen 2013). This book builds on that experience and on the digital identification tool MYCOKEY by the same two authors.

The two volumes (one for the introduction and covering most agarics and boletes, and a second one for crusts, polypores, ascomycetes and other fungi) enthuse, and make you want to look much deeper and in much more detail to find all those beautiful fungi.

Identification tools are not in the form of dichotomous keys but as so-called 'fungal wheels'—pie charts with the identifying characters as drawings and photos in the outer rings, where one starts in the middle and works one's way outwards to find the right species or group of species. I'd like to try these



with students and people who don't have any experience with fungi to see how effective these are. These wheels are free for download from the Mycokey website and can be used by everybody, whether you have the books or not: (www.mycokey.com/Downloads/FungiOfTemperateEurope_Wheels.pdf)

The text of the descriptions is in the form of a narrative, which always starts with the name of the species (no extras like author names or synonyms), gives the essential characters, followed by the habitat and distribution, and some remarks on other similar species. Conservation status of species, IUCN red data listings are given as well.

Space is not wasted in this book: the inside of the covers is used for the index and explanation of symbols, and a one-page explanation of often-used terms.

What are some of the other characters that make this book stand out?

—Inclusion of many species of crust fungi, small and inconspicuous ascomycetes, rusts, smuts, slime molds and fungi that do not form macroscopic fruitbodies but are often encountered (e.g. on rotten fruit). Also the astounding numbers of small *Agaricales* that is included is unique: e.g., five species of *Pseudobaeospora*, four *Mycenella* species, and 28 pages of inocybes. Even *Ceratellopsis aculeata* is presented (a tiny, tiny awl-shaped fruitbody on *Cladium mariscus* leaves). A total of 2,800 species! It must be said that this book is not an identification guide for the plant parasites (rusts, smuts etc.) and slime molds, but as they are conspicuous and show up at observation sites such as iNaturalist, their inclusion is definitely warranted.

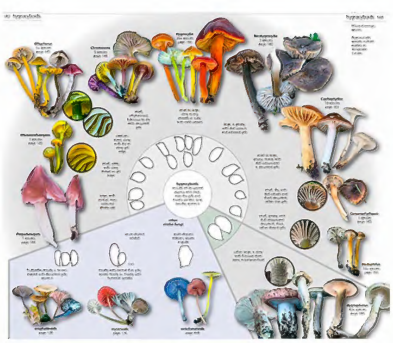
—The attention to detail—the insets with close ups of the important parts of the mushrooms;

—An introduction of almost 40 pages that cover many different aspects of mushrooms, the study of mushrooms, and the scope, geographic coverage, and lay-out of the book. Estimates are given for the species representation per group; e.g., an estimated 50% of gilled mushrooms from the study area is included (for small genera all species are included, but only a fifth of the *Cortinarius* species are represented).

—Group names on the top of the pages so that one knows where one is, without having to move back and forth through the book. An example of such a group: "large, dry ± colourful cortinarias with red-brown to orange-brown gills."

—Scale bars in the photos, no guessing about size anymore, and no need to give sizes in the descriptions.

—Because the species are grouped by shape not all species of a genus will be automatically together; this is obvious for truffle-shaped species and their agaricoid relatives but is also the case for genera with agaricoid and cyphelloid forms.



The only place I did not agree with the identification is for *Leucoagaricus americanus*—the photo shows *L. meleagris*.

An endearing character of these books is the narrow green ribbon that comes in handy to mark the pages with the identification wheels.

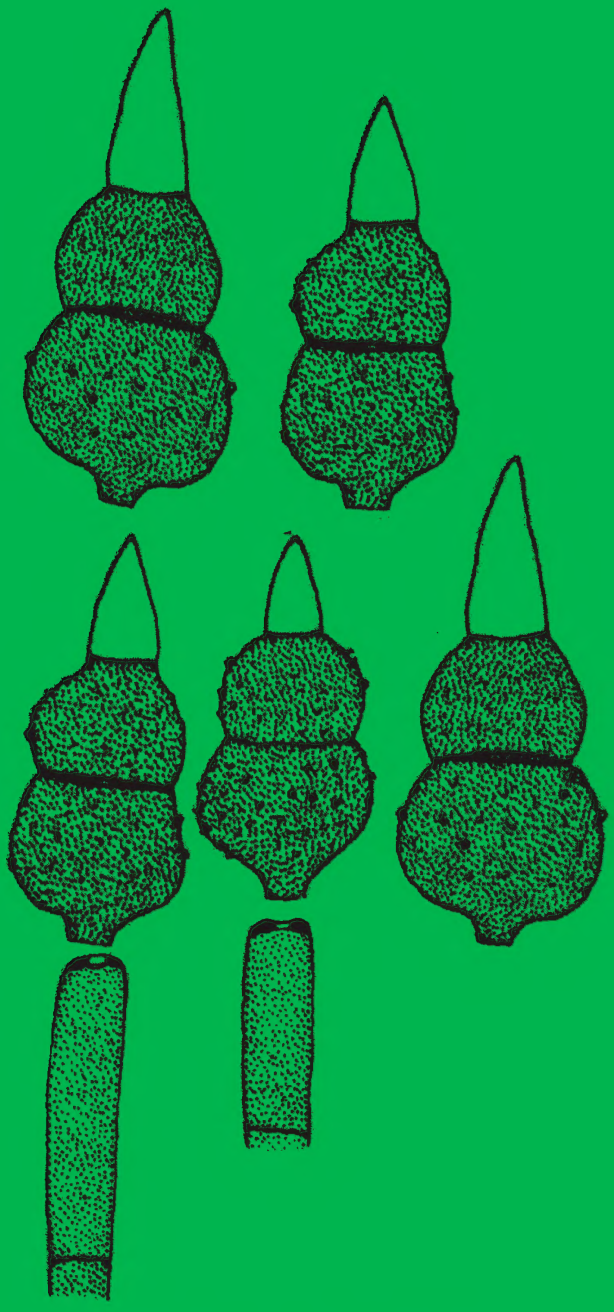
This is not a book to put in your backpack on your hike, as it is much too heavy. But it will be used back home, in the lab, with a microscope at hand.

Not only for people in Europe is this the best guidebook to get, it also is extremely useful for people in other parts of the world. It is a splendid example how to present the multitude of forms in a way that makes identification possible and fun, while at the same time showing the beauty and diversity of fungi.

Petersen, J.H., 2013. The kingdom of Fungi. Princeton University Press, Princeton. 265 pp.

Other recently published books:

Danmarks Svampeatlas 2009–2013. J. Heilmann-Clausen, T. Guldberg Frøslev, T. Læssøe, J.H. Petersen. 2019. Svampetryk, Kornblomsvej 6, 8381 Tilst, Denmark; svampetryk@svampe.dk ISBN 978-87-971178-0-4 350p. 300 DKR



Morganjonesia calophylli sp. nov.
(Zhang & al.— Fig. 1, p. 459)
Rafael F. Castañeda-Ruíz, *artist*